Factors influencing students’ choice of mathematics at university

by

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Submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

Deakin University

September 2014
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Factors influencing students’ choice of mathematics at university

submitted for the degree of Doctor of Philosophy

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ABSTRACT

Low enrolment in university mathematics has become a serious concern in many developed countries. Declining enrolment in university mathematics is seen as detrimental to educational, economic and industrial goals that are nurtured by this field. Attempts to find a solution to this problem have mostly targeted, with some level of success, reasons behind students’ lack of interest in taking mathematics subjects at secondary school or, more rarely, at university, through both government and privately funded longitudinal or cross sectional studies. This research shifts the focus from barriers and impediment to enrolling in tertiary mathematics to looking at the positive side by asking students already enrolled in university mathematics for their reasons for doing the subject.

The study selected first year university students as prospective respondents to a 42-item survey regarding factors that influenced their decision to choose university mathematics, or courses involving mathematics; their educational, cultural and economic background; and their attitudes and aspirations towards the subject of mathematics. Care was taken in choosing universities with large numbers of mathematics enrolments, which could therefore deliver the survey to more students and attract a higher number of respondents. Universities with more culturally diverse students were also selected in order to expand the range of responses. In total six universities agreed to allow their students to participate in the survey. From a population of approximately 8000 students who were enrolled in at least one first-year mathematics subject at these universities, 391 students completed the survey. Of these, 126 students indicated that they were prepared to be interviewed, resulting in a total of 27 students whose responses matched interview selection criteria being interviewed.

Data collected from the interviews were analysed using the framework of Eccles’ Expectancy Value Model of Motivation. Case studies were created for 11 students chosen from the 27 interview participants, each representing particular aspects of the interviewees’ selection criteria. The analysis revealed that Attainment value played a major role in students’ choice of university mathematics
and courses involving mathematics, as they valued and pursued their plan of what they wanted to be in future.

Nine factors were nominated by students, with the analysis relating these to the Eccles framework. Intrinsic value was evident in the factor *Enjoyment*, while the factors *Part of course*, *Prerequisite*, *Use in later career*, and *Mastery in subject* were related to attainment or utility value, depending on the survey respondents’ long- or short-term goals. *Maths experience* and *Did well at school* were combined into the factor *High school experience*, which provided evidence of expectation of success. Impediments to pathways for learning mathematics, such as inadequate instruction or assistance, and discouragement expressed – particularly by teachers, both primary and secondary – and peers, were considered as cost value.

There was a relationship between the factors influencing students’ choice and their chosen courses, as well as the amount of mathematics in the courses in which they were enrolled. Not surprisingly, students who elected to undertake a major in mathematics were more likely than others to list *Enjoyment* as a factor in their choice.

This study introduces new ways of investigating the problem of low mathematics enrolments at both secondary school and university, by highlighting the benefits and applicability of studying mathematics. Research into ways of promoting students’ interest in mathematics will benefit from the findings of this research, as will also research that is examining the impact of students’ background on their university course choice.

In addition, these findings, which provide another example of using Eccles’ framework in reviewing diverse purposes and motivations in academic choices, produce arguments for students to review their value prioritisation at the time of choosing their university courses by sharing genuine stories that are defined by students’ own words.
ACKNOWLEDGEMENTS

This PhD thesis is the finale of a long time journey in mathematics education that turned from an intense interest in exploring students’ attitudes towards choosing mathematics at university to, eventually, a precious conclusion to my lifelong career. A number of people significantly helped me to fulfil this aspiration and complete the project in the last few years.

It is a pleasure for me to thank them one by one for different roles they played in facilitating my achievement. First of all I would like to extend my sincere gratitude to my supervisors for their advice, encouragement and support. A special thanks to Associate Professor Susie Groves for constantly overseeing my work with a critical view and standing beside me when I needed help to sustain my optimism, to Dr Julianne Lynch for coming back to my supervisory team after Tex’s birth at the time I really needed her help for moving my project ahead through her innovative decisions, and to Dr Sandra Herbert for technical help, courage in providing new ideas, sharing her experiences and supporting me in lots of personal life ups and downs.

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On a more personal note I would like to thank my children for letting me believe in myself and keeping the world outside of my PhD active and alive. I am also highly grateful to my grandchildren for making me feel more determined in completing what I always wanted to do.

Finally I would like to thank my first year university classmate, my colleague, my best friend and full time companion who suffered most in this journey. No words can explain the gratitude that I feel for what he has done in the last few adventurous years.

This PhD has helped me to discover the magnitude of changes, the rise and fall that we can create in each other’s lives, and taught me to be appreciative of the unconditional help that I have received from others throughout this work.
CHAPTER 1  INTRODUCTION

Low enrolment in university courses involving mathematics has become a serious concern in many developed countries. Declining enrolment in university mathematics results in a declining number of academic staff and limits the amount of research in this area. This is detrimental to educational, economical and industrial goals that are nurtured by this field. Attempts to find a solution to this problem have mostly targeted, with some level of success, reasons behind students’ lack of interest in taking mathematics subjects at secondary school or, less frequently, at university, through both government and privately funded longitudinal or cross sectional studies. This research shifts the focus from barriers and impediments to enrolments in tertiary mathematics to looking at the positive side by asking students already enrolled in university mathematics for their reasons for doing the subject.

This first chapter discusses my personal background; introduces the complexity relating to the problem of the continuing decline in enrolments in mathematics at secondary school and university; states the rationale for the study, highlighting the role and importance of mathematics for Australia’s global competitiveness; and outlines the focus of the study, indicating its aim and significance.

1.1 Personal background

My attention was first drawn to the problem as a result of my perceptions and experiences while teaching mathematics in Australia’s higher education sector. Soon after commencing teaching, students’ various responses and different attitudes towards mathematics became my major focus and it gradually affected the nature and context of my teaching and, eventually, my job satisfaction. While some students displayed positive attitudes towards mathematics learning and were inclined towards a comprehensive exploration of the content, others were seen to put in the minimum amount of time and effort needed to pass their mathematics units, with some choosing not to enrol in further mathematics units after
completing bridging courses. Negative attitudes appeared to increase over my six
years of teaching in this organisation and enrolments in mathematics declined. It
became important to learn whether what I observed as students’ positive or
negative attitudes developed as a result of my teaching style or from other factors,
such as prior educational or cultural experiences. Many of the teachers and
lecturers with whom I worked had similar experiences teaching mathematics and
posed similar questions.

The complexity of the problem and the need to learn about reasons behind
students’ low enrolment in units involving mathematics led me to complete a
Master’s degree on adult students’ attitudes towards mathematics. Some
interesting facts about students’ decision making in choosing mathematics at
university, as well as about mathematics education in different countries emerged,
in addition to varied attitudes shown by students with different backgrounds and
experiences. For instance, some local students with a good knowledge of the
subject avoid enrolling in courses with more mathematics, whereas others with less
knowledge chose courses with considerable amounts of mathematics with no
hesitation. The results from my Master’s degree research provided the impetus for
this current study, which aims to explore factors influencing undergraduate
students’ choice of mathematics and their perceptions of the value of studying the
subject at university.

1.2 Rationale for the study

The continued decline in the number of students studying advanced
mathematics at secondary school is of growing concern nationally (Barrington,
2012; Rubinstein, 2009; Cairns, 2007; Forgasz, 2004). Over the ten years from 1995
to 2004, the proportion of Australian students in the Year 12 student population
taking Advanced Mathematics dropped from 14.1% to 11.7%, while the proportion
of students taking Intermediate Mathematics, but not Advanced Mathematics,
dropped from 27.2% of the Year 12 student population in 1995 to 22.6% in 2004
(Barrington, 2006).
In his more recent report, Barrington (2012) showed that, given the increasing Year 12 student population, the small rise in Year 12 advanced mathematics enrolment from 20,608 in 2011 to 20,786 in 2012 is actually part of an ongoing decline in students taking Advanced and Intermediate Mathematics. While “the proportion of Australian Year 12 students studying SOME mathematics in Year 12 has remained at about 80% for some decades” (Barrington, 2012, p. 2), the percentage of students taking Elementary Mathematics has risen, but advanced and Intermediate Mathematics has steadily declined between 2002 and 2012 (see Figure 1.1).

![Year 12 Mathematics Students in Australia - the last ten years](image)

*Figure 1.1. Percentage of Year 12 mathematic students enrolled in three levels of mathematics (Source: Barrington, 2012, p. 2)*

Students’ lack of participation in mathematics has been a matter of international concern for some time. For example in July 2003, the research group *Global Science Forum* reported “particularly worrying trends” in students’ interest in mathematics (Organization for Economic Co-operation and Development, 2004, p. 1). In Australia, according to the Australian Mathematical Sciences Institute (2013), there appears to have been a decline in the number of domestic graduates in the
mathematical sciences between 2001 and 2010, although the numbers need to be
treated with some caution, as data was not available from two large universities.

A review of mathematics and science education commissioned by vice-
chancellors of Australia’s eight “research-intensive” universities found the number
of students enrolled in a mathematics major at Australian universities declined by
15 per cent between 2001 and 2007 (Slattery & Perpitch, 2010). The review also
found the number of students taking Advanced Mathematics at secondary school
fell by 27 per cent between 1995 and 2007. Consequently this decline in numbers
influenced the intake of students into mathematics courses in higher education
(Chinnappan, Dinham, Herrington, & Scott, 2008) and brought about a reduction by
almost one third in academic staff teaching mathematics in the eight universities in
their study (Chinnappan et al., 2008). In Australia, the percentage of students
graduating with a major in mathematics or statistics is well below the Organization
for Economic Co-operation and Development (OECD) average and is continuing to
decline, while the demand for their skills is steadily increasing (Henderson &
Broadbridge, 2009; Ross, 2011; Sandland, 2013).

At the same time, data from the National Assessment Program – Literacy
and Numeracy (NAPLAN\(^3\)) shows “student performance in mathematics in Australia
has remained largely static over the last 5 years, with student performance not
going backwards or forwards” (Australian Mathematical Sciences Institute, 2013, p.
4). Perhaps more disturbingly, a recent report (Thomson, De Bortoli, & Buckley,
2014) highlighting Australian results from the 2012 Programme for International
Student Assessment (PISA), showed that while Australia’s average score in the PISA
2012 mathematical literacy assessment was significantly higher than the OECD
average, students’ scores had declined by the equivalent of half a year of schooling
over the ten year period from 2003 to 2012, while nine other countries had
significantly improved in their mathematical literacy performance during this
period.

Mathematics underpins many of the new technologies of science and
engineering, contributing “broadly to all disciplines and practices used for the

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\(^3\) The National Assessment Program Literacy and Numeracy (NAPLAN) is an annual assessment for
all Australian students in Years 3, 5, 7 and 9, carried out each year in early May.
betterment of society” (Committee on STEM Education, National Science and Technology Council (CSENSTC), 2013, p. 24). Without students skilled in mathematics, countries are hard pressed to stay globally competitive in these important growth areas. This concern is supported by the International Council for Industrial and Applied Mathematics, which noted in 2007 that the acute shortage of qualified mathematics teachers, university lecturers and other mathematics related professionals placed Australia’s research reputation and worldwide competitiveness in serious danger (Jeltsch & Wanner, 2009; CSENSTC, 2013).

Students are inspired and encouraged by teachers who comprehend the subject they teach so “the quality of teaching and teachers’ knowledge and attitudes seem to be an area of concern in students’ selection of mathematics subjects” (Chinnappan et al., 2008, p.6). The declining number of students taking higher level mathematics could be related to shortage of high school and higher education competent teachers, which also hinders higher education’s ability to meet the needs of industrial, scientific, and economic projects that are based on intensive mathematical knowledge (Holton, 2001; Chinnappan et al., 2008). Deterioration in mathematics results exacerbates difficulties in progress and development in these fields. Further evidence of the need for concern regarding Australia’s declining international ranking was provided by Dr Roslyn Prinsley at the time of her appointment as the National Science and Mathematics Education and Industry Adviser, when she stated “the problem has been well defined – why isn’t Australia at the top of mathematics and science performance when we are among the richest and most privileged countries in the world?” (Australian Government, 2012). Australia’s Science, Technology, Engineering and Mathematics (STEM) enterprise must be globally connected to maximise advantage to be a contributor to, and a beneficiary of, the global search for solutions to problems that confront the planet (CSENSTC, 2013).

The need for more mathematics graduates requires consideration of a broad overview on a wide spectrum of contributory factors, such as university policies in attracting more students into the field, and school strategies to encourage students to undertake more mathematics. My own interest as a tertiary mathematics educator is in the diversity of attitudes and experiences of students who are
studying university mathematics. Rather than pursuing the many possible ways of understanding reasons behind low enrolment in University mathematics, I want to understand better those students who do choose to study mathematics. What motivates them to select mathematics in the course of their studies? What aspects of their backgrounds or past experiences do they attribute to this decision?

Research into declining participation in formal mathematics education has mostly focused on attitudes of secondary students and their interest in choosing the subject (Marks McMillan, & Hillman, 2001; Khoo & Ainley, 2005; Tytler, 2007; Russell & Houston, 2010). Many studies that looked at students’ intention of taking the subject at tertiary level showed concern only for potential students’ purposes (Jordan, Cretchley, & Passmore, 2007; Panizzon & Westwell, 2007, 2009; Chinnappan, et al, 2008; Rubinstein, 2009), rather than current students’ reflection on paths taken and decisions that had already been made.

Most studies have identified barriers and deterrents to choosing mathematics (Langen & Dekker, 2005; Pollacia & Lomerson, 2006; Grootenboer, 2007; Cho, Jones, 2008; McPhan, Morony, Pegg, Cooksey, & Lynch, 2008; Malthus & Fowler- Nelson, 2009; Wu, 2009; Olatunde, 2010), rather than investigating what motivates or supports students to continue with their mathematics education. Some studies that investigated post-secondary-school mathematics examined university guidelines and entrance requirements posing barriers to entering tertiary mathematics (McInnis & James, 1995; Ainley, 2004; Maringe, 2006; Heiat, Brown, & Johnson, 2007; James, 2007). Furthermore, most of these studies were carried out using survey data of longitudinal studies run by governments. In my study, I wish to complement existing knowledge by focusing on current undergraduate mathematics students and the reasons why they have chosen to undertake tertiary level mathematics.

1.3 Focus of this study

The aim of this study is to examine the reported backgrounds, experiences and opinions of current undergraduate mathematics students, with a view to exploring the complexity of factors that influenced their decision to study
mathematics at university. The intention is to focus on the stories of students who are interested in mathematics, in contrast to the many research findings reporting attitudes of those who do not like mathematics or who chose not to study mathematics at tertiary level. Significantly, this research highlights students’ successful experiences and positive attitudes towards mathematics by focusing on current students’ explanations of why they chose to study mathematics at university. Students’ educational, cultural, social and financial backgrounds, as well as the value they ascribe to mathematics education, are examined in this research.

Reasons that motivate students to undertake mathematics at university, their perceptions of secondary school mathematics, pathways after finishing secondary school, perceptions of the value of university mathematics, and the impact of their cultural backgrounds on these, are studied in this project.

To investigate different factors that might have influenced students choosing mathematics at university, I conducted a survey of students who were newly enrolled in mathematics at university. In order to further explore these complex factors and the relationships between them, this large student survey was complemented by a number of extended interviews. I wanted to identify the main factors that encouraged students to become interested in mathematics, and the reasons that motivated them to choose university courses involving mathematics, as evident in their own accounts of their backgrounds and of their educational and career trajectories. Part of my motivation, as someone who has admired and enjoyed mathematics, and who has benefited from studying it, is to document the positive side of learning mathematics in the hope that understanding this can assist in communicating the appeal of mathematics to prospective students.

Exploring the complexity of influential factors and their possible connections with students’ educational, cultural, social, and financial backgrounds may encourage further research in this area that focuses on the positive aspects.

The next chapter reviews literature relevant to this thesis, including existing empirical studies of factors influencing participation in mathematics education and other areas of literature and theory that have influenced the current study.
CHAPTER 2 LITERATURE REVIEW

This chapter aims to examine the factors influencing a student’s choice of mathematics study as investigated in previous studies. The review starts with literature on decisions to pursue tertiary studies more generally, and then on research specifically relating to the decision to pursue tertiary mathematics. Theories of motivation are identified as significant to the study and are discussed, including individual and social views of motivation, internal (intrinsic) and external (extrinsic) motivation, theory of choice, cultural effects on choice, and the expectancy value theory of motivation. The study’s theoretical framework and its positioning are then presented before concluding the chapter with a brief overview.

2.1 Deciding to pursue tertiary studies

The following section discusses research into the factors influencing the decision to pursue undergraduate study. This includes psychological, socio-economic, educational, and demographic variables impacting on the decision to pursue undergraduate study; trends in student pathways to university; and, the characteristics of students who successfully transition to university study.

2.1.1 Background variables influencing students’ decisions to pursue undergraduate study

In Australia, knowledge about students’ choices of university in the transition period from secondary school to tertiary study are mostly based on evidence derived from large-scale government commissioned surveys of university students that sought to determine correlations between student background variables and their educational choices (McInnis & James, 1995; Panizzon & Westwell, 2007; Khoo & Ainley, 2005). Most of the other literature regarding the transition from school to university is either focused on first-year university students, for example Marks et al. (2001), or specifically targeted groups of students like Forgasz (1998) who examined cultural background and Anderson (2005) whose work concentrated on vocational studies.
The main variables identified in the literature are: psychological factors, socio-economic background, educational background and ethnicity.

**Psychological factors**

Theories on transition in the early 1970s that emphasised the psychology of individual characteristics gradually changed focus to sociological factors and, recently, to the institutional context and student integration (Evans, 1999). Pursuant to Evans’ (1999) identification of psychological issues as the first factor in student transition to higher education, Marks et al.’s (2001) longitudinal study indicated that students’ self-concepts of ability, their educational aspirations and the influence of their parents, in increasing order of importance, had the greatest impact on their decisions. Here self-concept means students’ beliefs about their ability to learn mathematics and to conquer challenges over certain levels of success in achieving their mathematical goals (OECD, 2013). Other studies, for example, Ashworth and Evans (2001), Khoo and Ainley (2005), Ma (2006), Kleanthous and Williams (2010), Olatunde (2010), Ozturk, (2001), Rodd, Mujtaba and Reiss (2010), have found complex links between attitudes, engagement, and participation.

**Socio-economic background**

Transition from secondary school to university is considered a rite of passage for many young people (Clark & Lovric, 2008), particularly those from middle class families and families with a history of university participation. Historically, mature individuals (e.g. parents, teachers) have been able to influence and assist students (Ugorji, 2009; Werfhorst, Sullivan, & Cheung, 2003) with these individuals often possessing formidable intellectual, social, and psychological skills (Miller, 2010; Schagen & Hodgen, 2009). However, with the widening of university participation to include non-traditional student groups, not all students have access to such influence and assistance (Creed, Patton, & Bartrum, 2004).

The early emphasis on psychological factors as discussed by Fenigstein, Scheier and Buss (1975) has expanded to include sociological variables, such as the socio-economic background of the student (Acker-Ball, 2007; Fullarton, Walker,
Ainley, & Hillman, 2003; Goodman, & Gregg, 2010a; Lyon, 2004; Ma, 2009; Meng, 2005; Rochat & Demeulemeester, 2001; Valadez, 2002). Young people in Western society increasingly face numerous decisions in their move from secondary to tertiary study (Broucker, 2005, cited in Simons, Beavis, Neola, & Considine, 2005). For instance, they often combine work and study over an extended period (Simons et al., 2005) or are financially reliant on parents. These economic situations provide different challenges and stressors for the new higher education student (Okediji, Offiong, Umoh, Sanni, Ezeh, & Afolabi, 2008; Salami, 2007).

Some other surveys show that in many cases lack of financial support plays a part in students’ decisions to leave education for the workforce after finishing secondary school (Reay, David & Ball, 2005; Simons et al., 2005). Findings from Tang, Pan, and Newmeyer’s (2008) survey revealed that students from financially unstable families were more likely to leave secondary school to join the workforce.

A 2009 survey of students who had selected to continue education, commissioned in England by the National Union of Students (NUS), showed that many students choose the cheaper option when applying for university rather than seeking entry to the course or institution which best suited their interests (see also Latu, 2004; McInerney, DiDonato, Giagnacova, & O’Donnell, 2006) or rely on their abilities (NUS, 2009). Socio-economic variables other than financial security are considered as important issues in choosing higher education. For example, parental occupational status has the largest impact on some students’ decision to pursue tertiary study, followed by parental wealth and parental education (Schnabel, Alfeld, Eccles, Köller, & Baumert, 2002; Davis-Kean, 2005; Rochat & Demeulemeester, 2001). Variables linked to socio-economic status are correlated with the tertiary entrance decision according to a longitudinal survey by Marks et al. (2001), which is supported by the research of others such as Davis-Kean (2005), Simpkins, Davis-Kean and Eccles (2006), Tsagala & Kordaki (2007), and Williams, Pampaka, Black, Davis, Hernandez-Martinez, & Wake (2007).

**Educational factors**

Institutional context and student integration is regarded as significant influences on students’ decisions to seek entry to post-compulsory education.
(Evans, 1999). Researchers have found that variables such as secondary school academic performance (Bourke & Smith, 1989; Creed et al. 2004), literacy and numeracy levels (McInnis & James, 1995), school sector (Marks et al., 2001; Khoo & Ainley, 2005; Rimmer & Houston, 2010), and attitude to school (Bourke & Smith, 1989; Manning, 1988; Ryan & Watson, 2004; Cardak & Ryan, 2009) also impact strongly on students’ tertiary entrance decisions. Literature on transition from school to university (Bourke & Smith, 1989; Khoo & Ainley, 2005; Manning, 1988; Marks et al., 2001) which analyses the tertiary entrance performance of Year 12 students in Australia, addressed a variety of issues including students’ Year 12 experiences and personal interests relating to tertiary entrance performance (Wu, 2009; Gorard, & See, 2009; Knowles, 2010). Another longitudinal survey (Khoo & Ainley, 2005) and a study by Tang, et al. (2008) found that students who are positively oriented to school and are actively engaged in academic work and other activities are more likely to develop intentions to continue their education through secondary school and into tertiary study.

After Marks et al.’s (2001) and Khoo and Ainley’s (2005) studies, Gorard and See (2009) concluded that attitudes to school are strongly related to higher education intentions and socio-economic background. Marks et al. (2001) found attendance at independent schools results in higher scores than attendance at Catholic schools, which in turn produce higher scores than government schools. They noted that higher scores could be translated into an increased likelihood of being accepted into university programs.

**Ethnicity**

There is less available research literature on the role of ethnicity compared with other potential influences on the decision to enrol at university. However, existing studies suggest that ethnicity plays an important role in students’ planning and decision-making about their tertiary studies (Marks et al., 2001; Keshishian, Brocovich, Boone, & Pal, 2010). An Australian study argued that students of ethnic minority backgrounds are more likely to perceive higher levels of support from parents in terms of their decision to go to university (Bowden & Doughney, 2010). A longitudinal survey (Marks et al., 2001) revealed that the percentage of students
with fathers born in non-English speaking countries who participate in higher education in Australia is higher than that for students with Australian-born fathers.

Khoo and Ainley (2005) found that students with non-English speaking backgrounds demonstrated greater intention to engage with post-compulsory education. The significance of ethnicity is confirmed further in Birrell’s (1994, as cited in Evans, 1999) discussion of family support and Keshishian et al. (2010), who found that Greek and Asian students with high family support showed very high levels of motivation to enter university and lower attrition rates in comparison with Caucasian students (Evans, 1999; Dawson, 2007; Pearce & Lin, 2007). In addition, a study of Year 11 and 12 students’ choices of mathematics in a Sydney secondary school showed parental ethnicity to be a significant influencing factor (Awad, 2008).

Gorard and See (2009) in cultural background research with students from multicultural society claimed that family financial status impacts on students’ education and engagement at university. The study found that a family’s financial status is a mediating factor in decisions to pursue university study.

While four major correlates with students’ choice of tertiary education have been reviewed above, other variables and factors that feature to a lesser extent in research and also play important roles in decisions to pursue university education will be considered next.

**Other factors influencing decisions to enrol at university**

Other variables and factors identified by researchers as influencing the decision to pursue a university education include: state or territory differences in terms of achievement, tertiary entrance performance, and gender (Marks et al., 2001; van Langen & Dekker, 2005; Ma, 2006); effects of individual school and university entry policy (Khoo & Ainley, 2005); future occupational plans (Simons et al., 2005), and personal and social fit (James, 2002b).

James (2002b) claims that most students are guided by published course and career information and do not have enough knowledge to make the right academic decisions, while university admission procedures play a social sorting role with little concern for students’ experiences or the quality of their experiences (James, 2000). Commenting on the massification of higher education in England, James (2007)
suggests that many equity issues, in terms of access to higher education, remained unresolved and the expansion of universities has increased the intensity of competition for higher status and entrance to more selective universities.

In summary, psychological factors (Song & Glick, 2004; Khoo & Ainley, 2005), socio-economic (Ma, 2009; Marks et al., 2001), educational variables (Manning, 1988; Ryan & Watson 2004; Cardak & Ryan 2009), ethnicity (Khoo & Ainley 2005; Keshishian et al., 2010), and other variables such as university entry policy (Bourke & Smith, 1989; James, 2007) have significant influence on students’ participation in tertiary study. The next section will review literature on trends in student pathways to university.

2.1.2 Trends in students’ pathways to university

In Australia commencing higher education most frequently starts immediately after finishing secondary school, although there appears to be an increasing trend for some students postpone their studies for various reasons (McInnis & James, 1995; Young, 2007; Martin, Nejad, Colmar, Liem, & Arief, 2013). The journey from school to university is for many students into an unknown territory that leads them to expect great changes in their educational lives that involves excitement but also presents many challenges (Johnston, 2001). For these reasons, it is not uncommon for students to have a gap before they commence their tertiary studies. A longitudinal survey of Australian youth (Lumsden & Stanwick, 2012) found that the percentage of students taking a gap year between completion of secondary school and commencing university increased by 10% between 2000 and 2010. The findings of this survey show that taking pathways other than a conventional higher education course after completion of secondary school has become a popular trend among Australian students, who may join the workforce, take a trip, carry out a course, or just have a break from formal studying. Other alternate pathways include returning to study after a period of employment, and entry into university study via a pathway that does not include Year 12 study.

A recent study, looking at a cross section of secondary school students as well as university students, reported that school students are more interested in
taking a gap year if they are not certain about the courses they want to do at university or are not motivated about academic life (Martin et al., 2013). However research conducted by Jones and others (as cited in Lumsden & Stanwick, 2012, p. 10) suggests that students who take a gap year prior to commencing their undergraduate study are more motivated, gain better results and are less likely to drop out of university than those who did not defer their studies.

### 2.1.3 Student characteristics for successful transition to university study

Research shows that students enter higher education with a “history” of certain characteristics, expectations, skills, goals and commitments that continuously correspond with their ability to integrate themselves socially and academically (Tinto, 1993, Forgasz, 1998; Marks, et al., 2001; Surry, 2006). Students with preset goals, an understanding of the subject area and a clearer view of university are most likely to succeed in their transition process (Marks et al., 2001). Furthermore, it has been shown that secondary school students who want to explore better career and employment opportunities (Heiat et al., 2007; Maringe, 2006) become more familiar with the university environment prior to commencing a university course (James, 2007). Students who are able to build advanced knowledge and practice, develop higher skills, improve their social contacts and activities and secure their future are more likely to successfully transition from secondary school to higher education (Chickering & Schlossberg, 1995; Young, Fraser, & Woolnough, 1997; Degrazia, Sullivan, Aragon, & Matthews, 2001).

The period of transition from high school to university is a crucial time as it determines the future directions of students (James, 2007). It is at this time that they choose a university course that most likely will eventuate in a career path (Marks et al., 2001; James, 2002a; Bexley, James, & Arkoudis, 2011) and they are preparing to cope with upcoming changes in their academic, social and personal lives (Bentley, Coates, Dobson, Goedegebuure & Meek, 2013).

This section has reviewed literature on background variables and factors influencing students’ pursuit of university education. The next section will review
literature that specifically focuses on students’ decisions to choose mathematics at university.

### 2.2 Choosing tertiary mathematics

It appears that decisions about tertiary education are influenced by a range of variables including demographic, socio-economic, cultural and educational background, as well as other psychological factors. Informed by Martin and Munns (2005) framework of student motivation and engagement, these influences can be divided into social and psychological factors. In the review below of literature on students’ decisions to study tertiary mathematics, social influences are further divided into social and institutional factors, where,

- Sources of social influence on choice of university course include social background variables such as socio-economic background, ethnicity, culture and gender, and significant others such as parents, peers and friends;
- Sources of institutional influence on choice of university course include career information, academic support and students’ self-efficacy; and
- Sources of psychological influence include constructs such as self-concept of ability, sense of autonomy, attitudes toward mathematics and belief in mathematics.

#### 2.2.1 Social factors

Some researchers have studied the influence of social background variables, such as family background, socio-economic background, ethnicity, culture and gender on subject choice and choice of university. Others have studied the direct influence of parents, friends and peers, or a combination of these and background variables. Existing literature on these social factors is reviewed next.

*Family background in mathematics*

Findings from the *Program for International Students Assessments* (PISA) suggested that in addition to being involved in their children’s education, parents influence children’s study and study goals by providing a supportive home
environment, educational resources, and a model for learning (Davis-Kean, 2005; Hannula, Kaasila, Pehkonen, & Laine, 2007; Ma, 2009) as well as values towards mathematics (OECD, 2003). Other research indicated that outstanding science and mathematics students are influenced by the career aspirations and achievements of their parents (Bandura, Barbaranelli, Caprara, & Pastorelli, 2001; Lyon, 2004; McPhan et al., 2008; Panizzon & Westwell, 2009; Tytler, Osborne, Williams, Tytler, & Clark, 2008). As parents’ education and careers are often correlated with socio-economic background, this background variable is discussed in the following section in terms of its impact on students choosing mathematics.

Some researchers believe students’ engagement with mathematics is determined by psychological factors such as their belief or understanding about their capability in doing the subject or “mathematical identity”, which is constructed by their mathematical experiences (Hannula et al., 2007). The effect of family on students’ mathematical identity varies between countries and cultures (Salami, 2007; Woessmann, 2004), thus family background variables interact with ethnic background. For example, because Science, Technology, Engineering and Mathematics (STEM) related careers in developing countries such as Iran, India and China are well paid, parents and society value these fields and actively encourage students to engage in these subjects (Hobart, Young, Mills, & Gill, 2006). The goal is help children to improve their socio-economic status and escape the poverty cycle (Ma, 2001, 2009; Watt, Richardson, & Pietsch, 2007; Lowell & Salzman, 2007, as cited in Panizzon & Westwell, 2009). Panizzon and Westwell (2009) added that these developing countries are currently over-supplied with citizens qualified in STEM-related fields, while OECD countries struggle to fill available positions in these areas.

**Socio-economic background**

One of the most enduring findings of educational sociology is the relationship between parents’ socio-economic status and students’ schooling outcomes. Sui-Chu and Willms (1996) claimed that parents from higher socio-economic backgrounds spend more time on their children’s education than those from a lower socio-economic background spend. This greater level of parental
involvement results in students’ higher educational achievement, although why this varies from student to student is not yet known (Dustman, 2004; McConney & Perry, 2010).

The interaction of socio-economic status and gender is also emphasised in several longitudinal studies, although these findings are not uniform. An Australian longitudinal study (LSAY) identified socio-economic background as one of the strongest influences on tertiary entry performance, together with literacy, numeracy, ethnicity, gender, and school (Marks et al., 2001; Ryan & Watson, 2009). An American study showed that socio-economic background is a greater influence on female than male students when they chose subjects at university. Trusty, Chester, Maximino, and Kok-Mun (2000) also claimed that gender interacts with socio-economic background in relation to academic performance. Conversely, an Australian study (McConney & Perry, 2010) that considered the effect of school SES on students’ performance found that mathematics achievement is stronger for students of lower SES than students of more privileged schools (McConney & Perry, 2010). Their research concentrated on two groups of 15 year-old mathematics students in low and high SES secondary schools and found that students from low SES achieved higher than students from high SES secondary schools, even though both groups were regarded at the same level of self-efficacy apart from their individual SES. This finding suggests that self-efficacy is more directly influential on mathematics achievement than socio-economic status and that studies finding lower achievement in low SES groups may be in fact measuring the effect of self-efficacy that varies in relation to socio-economic status.

**Ethnicity, culture, and gender**

The growth of the global educational market in higher education necessitates an understanding of cultural differences in terms of student motivation. In addition, understanding students’ varying viewpoints and cultural values offers insight into the reasons behind behavioural variations that emerge from different levels of motivation (Bishop, 1994; Felder & Brent, 2005; Kobayashi & Viswat, 2007).
Comparative analysis of motivation has examined the attitudes of students from different cultures towards schooling. For example, Kobayashi and Viswat (2007), in their article *Cultural Differences in Motivation to Learn*, argued that Japanese modesty, American straightforwardness, and Asian politeness in teacher interactions and classroom environments affect students’ decisions about their field of study and individual subjects (Kobayashi & Viswat, 2007; Meldrum, 2006; Zhu, 2007). In another study of junior high school students in Israel, Asian students showed more interest in courses based on quieter activities with low verbal performance requirements, whereas fewer Asian students enrolled in courses with seminars and representational involvement (Trumper, 2006). Research into the factors that sustain STEM career pathways found Asian students achieving higher scores than their American counterparts (Borman, Hanson, & Tyson, 2004).

In support of the importance of an individual’s identity as a cultural construction, Hoffman asserted that, “identity has become the bread and butter of our educational diet” (Hoffman, 1998, p. 324, as cited in Hmelo-Silver, 2004). This emphasises the impact of student characteristics on education, portraying each person as a complicated construction of psychological, sociological and environmental factors, which makes the task of determining motivation for behaviour even more challenging. In fact, students are considered complex social units of multiple variables such as family (Harris, 2007) or study background and personal interests (Pedrosa, Dachs, Cibele, & Andrade, 2006; Phelan, Davidson, & Cao, 1991, as cited in Lyon, 2004). Thus, students react differently and uniquely towards tertiary study and educational institutions (Forgasz, 1998).

Olatunde (2010), Salami (2007), Reay et al. (2005), Young et al. (1997) point out that no one strategy works for everyone when studying motivational issues. A survey of students from 17 countries also reported different cultural patterns relating to different motivational results either in the selection or non-selection of a mathematics curriculum (Davis, Williams, Hernandez, Nicholson, Pampaka, Wake, Hutcheson, & Kleanthous, 2008).

Some studies suggest that ethnicity, culture, and gender interact to produce particular trends in terms of choice and enrolment in mathematics. In Australia, ethnicity and gender were found to be variables influencing students’ choice of
subjects, along with educational and socio-economic background (Marks et al., 2001). A questionnaire evaluating factors affecting students’ choice of STEM subjects in higher education in America produced different findings when the study examined the demographic, pre-college, environmental, and college factors that impact on Hispanic students’ interest in earning a STEM degree. Results indicated that, for this cohort, earning a STEM degree was influenced by ethnicity, gender, and secondary school percentile. Findings indicate that gender and ethnicity may be significant variables in the involvement of Hispanic students in mathematics (Crisp, Nora, & Taggart, 2009). Similarly, a 2008 study commissioned by the Higher Education Funding Council for England found that the gender gap in post-16 years of age uptake of mathematics and physics was larger in England than it was in Scotland, Ireland and Wales (Joubert & Andrews, 2010).

Some studies into participation in mathematics have focused either on ethnicity or gender. Focusing on gender, Fullarton et al. (2003) conducted a longitudinal survey of Year 12 students and discovered differences between the participants in advanced mathematics in terms of gender, with male students showing more interest in undertaking these subjects. In another study on students’ reasons for choosing science and information system courses, long-term gain influenced male students more than other considerations, whereas the most important reason for female students was their absolute interest in the subject (Jones, 2008).

Focusing on ethnicity, a cohort study involving 91,000 secondary school graduates through college up to graduation in 1996-1997 and 2002-2003 examined the influence of ethnicity on choice of STEM subjects in higher education in Florida, USA. The study, which examined the secondary school and post-secondary school educational pathways and course-taking and achievement STEM pathways using mathematics and science courses for Florida public secondary school graduates, revealed that the Asian students in general achieved higher grades than the American students (Borman et al., 2004). A literature review in New Zealand has claimed a significant influence of ethnicity in the choice of science among senior secondary school students (Hipkins, Roberts, Bolstad, & Ferral, 2006). Studies have
also reported an interaction between ethnicity and the influence of parents on subject choice, as discussed in the next section.

In the UK, ethnicity has been strongly associated with choice of mathematics by first-year undergraduates, in addition to other factors such as gender and self-concept (Rodd et al., 2010). However, Ruthven (2010) found that students’ self-concept was the major factor in choosing mathematics, independent of ethnicity and gender. This finding is similar to that of McConney and Perry (2010), noted earlier, where psychological constructs such as self-concept and self-confidence were found to be strongly related to decision-making and in relation to mathematical study are correlated with other social background variables such as ethnicity and socio-economic background.

**Influence of parents in choice of university course**

Numerous studies show high levels of parental involvement in subject selection at secondary school, but less in choice of course at university (e.g. Bowden & Doughney, 2010; Davis-Kean, 2005; Kleanthous & Williams, 2010; Ma, 2001, 2009; Miller, 2010; Ozturk, 2001; Reay et al., 2005; Valades, 2002). The influence of parents on students’ educational choice has usually been investigated through the influence of career aspirations, educational background, and socio-economic background. For example, research into 1425 Grade 7 to 10 students in the USA and 1755 Grade 7 to 10 students in Germany found parents’ careers, education, and socio-economic background as the major variables influencing subject choice (Schnabel et al., 2002). Similarly, in 2002, in Australia, Watt et al. (2007) investigated factors that influenced 245 STEM candidates at secondary school and found parents’ careers and education as the most influential variables for career selection and course choice at secondary school. Some studies (e.g. Marks et al., 2001; Panizzon & Westwell, 2007) found these variables effecting students’ choice of university course as well.

In another study, parents were identified as the main influence on students’ choices of science subjects in Year 13 in New Zealand (Hipkins et al., 2006). A strong effect of parents on subject choice at university, as well as secondary school was identified also in a study of student attitudes to physics in the UK (Knowles, 2010).
Peers and friends

The influence of peers and friends on motivation and decision-making has been found to be significant in the general literature on motivation. For example, the psychological construct social competence which interacts with confidence and motivation has been related to children’s experiences with friends and peers (Ryan, 2009). Peer influence has also been found to contribute to students’ self-esteem as well as their functioning in social fields and academic domains (Wentzel, 2005). However, some suggest that the impact of peers and friends on the decision to study mathematics is lower than that of other factors (Piotrowski & Hemasinha, 2001). Meanwhile, there is evidence that students with a better understanding of mathematics usually support their low achieving friends, while underachieving students showed higher results under the influence of peers who are stronger academically (Fullarton et al., 2003).

An American study by Eccles, Adler, Futterman, Goff, Kaczala, Meece and Midgley (1983) found children’s concepts of their competence is usually influenced by the perceived support from others such as close friends, classmates, teachers, and parents. Influence of peers on students’ confidence, self belief and efficacy starts from the first year of schooling and in many cases continues until the final years of schooling. An Australian longitudinal study conducted on several hundred children in pre-school years found that academic adjustment, social behaviour and emotions mostly related to students’ early relationship with carers, teachers, and other social participants (Bowes, Harrison, Sweller, Taylor, & Neilsen-Hewett, 2009). Another Australian study (Gervasoni, 2004) concerning mathematical achievements found a 40% gap between students’ achievements in the first year of schooling. The shortfall affected most students’ confidence in their ability to progress in that particular field, and continued until the final years of schooling in many cases. Some students who underperformed in mathematics compared to their peers in the early years of study remained behind until the end of secondary school and did not enroll in advanced secondary school and university mathematics, which requires more investigation (Gervasoni, 2004).
2.2.2 Institutional factors

Institutional factors in conjunction with social factors that impact on students’ decision making are divided below into: reduced government funding to universities; pathway and admission advice and policies; academic support; career information; and the influence of teacher self-efficacy.

Reduced government support and funding to universities

This section concerns government policy and funding programs that directly or indirectly support access to and participation in higher education mathematics courses, including both broader policies for funding university course provision and participation and specific funding aimed at increasing equity and access to higher education.

Support strategies that might encourage students to participate in higher levels of mathematics unfortunately remain very limited in Australian systems (Chinnappan et al., 2008). Lack of support strategies, such as generic skill support programs, could be due to low government funding generally in tertiary education (Bamforth, 2010), with spending in the field of mathematics by Commonwealth, State and Territory governments decreasing between 1992 and 2009 (Australian Mathematical Sciences Institute, 2013). Further funding cuts suggested recently by governments relating to research training, grants, awards, scholarships, vocational higher education, as well as proposals for higher or deregulated students fees including in the fields of mathematics and science, provoke concern in for support strategies and public education in general in Australia (Kniest, 2014).

Moreover, the lower rate of government funding for mathematics courses at university, compared to some other disciplines, effects the offering of mathematics degrees at some universities (Thomas, 2009). The Discipline profile of the mathematical sciences, 2013 (Australian Mathematical Sciences Institute, 2013) shows that changes to funding have resulted in a lower number of courses involving a major in mathematics being offered by universities. It is important to note that the impact of low government expenditure has had a greater effect on lower SES areas and regional areas (Australian Mathematical Sciences Institute, 2013). Some
government policies and programs focus on demographic groups who are identified as being underrepresented in higher education pathways. For example, the Higher Education Participation and Partnerships Programme (Australian Government Department of Education and Training, 2015) targets people from low socio-economic backgrounds, underrepresented ethnic groups, and people from non-traditional backgrounds such as mature aged students (O’Shea, Onsman, & Mckay, 2011). These funding programs often translate into institution-level strategies to promote participation and success of underrepresented groups, which are referred to here as support strategies (O’Shea et al., 2011).

Pathways, admission advice, and policies

In the competitive university environment, most candidates are not aware of what is and what is not achievable for them because they do not know the required score for their performance against the entry standard for the university course in which they wish to enrol (James, 2002b; Khoo & Ainley, 2005). Some studies note that even the highest-achieving students may not actively seek information about university courses and as a result accept information about the higher education market mediated through the media or by school advisors (Burton, 1999).

Students who move from secondary school to university are required to make important decisions regarding which subjects to study and which to discontinue. Some students are not aware of the impact of their choice of final secondary school subjects, nor do they understand the impact of their assessment results on their university education, and, ultimately, the type of job and career they can pursue (Forgasz, 1998; Chinnappan et al., 2008).

The choice to continue with science, mathematics or technology in the final years of schooling has consequences for students’ subsequent tertiary studies and career opportunities (Harris, 2005). Some students who struggle with their mathematics subject at university complain of a lack of knowledge about the correlation between their high school mathematics and what they are expected to understand at university (McNaught & Hoyne, 2011). A national survey in Australia found that the connection between senior secondary school subjects and their
effect on university entry scores is not regarded as important by the education system and is poorly understood by students (Chinnappan et al., 2008).

Clearly, the pressure of competitive entry based on academic performance is a powerful influence on the decision-making processes of students – including students in courses involving mathematics, such as engineering – when entering undergraduate study through conventional pathways (James, 2002b; Young, 2007). Numerically, the largest group entering universities are school leavers and many of these students – up to a third, according to Krause, Hartley, McInnis and James (1995) – are not admitted into their first choice of course (Young, 2007) because their entry score is not competitive.

Poor mathematical background can become an intractable barrier for students, ending their higher education aspirations, as earning a degree, certificate, or even a licence, usually requires some mathematical skill (McNaught, & Hoyne, 2011). However, the relationship between course requirement and competencies necessary for success seems often not to have been clarified by career advisors (Chinnappan et al., 2008).

**Academic support**

Academic support in this section refers to programs and strategies offered by teaching staff and guidance teachers during students’ final years of high school, to help them towards university education and ultimately the choice of university course. Eccles (2009a) suggested that academic support stabilises students’ personal interest in a particular field. Furthermore academic support enhances students’ engagement and helps develop their success in choosing and progressing in their major and is found essential in active learning practices (Kuh, 2008).

The impact of interest in a subject on decision-making has been found to be associated with quality of school teaching and the academic support students receive in the process of transition from secondary school to university (e.g. de Almeida, Leite, & Woolnough, 1998; Chinnappan et al., 2008; Ugorji, 2009). Werfhorst et al. (2003) also argued that achievement in mathematics is related to the choice of subject at university, as students usually choose subjects that they are
relatively good at compared with other subjects. Thus programmes and strategies that support achievement can indirectly support interest in further studies.

Moreover, Marks et al. (2001) found that Year 9 literacy and numeracy performances are more effective markers of future subject choice than the demographic and other social characteristics suggested as influential by other researchers. Again, this suggests that academic support during school can increase both achievement and interest that might later translate into decisions to pursue undergraduate mathematics. Surprisingly, despite its high importance, final year secondary school subject combinations and their cumulative effect on students’ tertiary field and career decisions, as influenced by their academic results and interest in subjects, has not attracted much research or funding (McInnis & James, 1995). Ainley (2004) also noted that students’ patterns of subject choice in later secondary school years are based on success in those subjects during earlier years of schooling. This pattern might extend to their choice of higher education courses as well.

On the other hand, international research on the decline in students’ uptake of STEM related subjects at school relates directly to primary and secondary school science teachers’ failure to excite student interest and engagement (Borman et al., 2004; Mapolelo, 2009; Piotrowski & Hemasinha, 2001; Tytler et al., 2008). According to Tytler (2007), much of this decrease in students’ interest takes place between Year 4 (87% interested) and Year 8 (69% interested). Supporting this argument, some other reports claimed that some secondary school students see school science, including mathematics, as uninteresting, unimportant, and irrelevant to their lives (Chinnappan et al., 2008; Tytler, 2007; McPhan et al., 2008; Panizzon & Westwell, 2009). This attitude may affect students’ university subject choices in later years as uninteresting content or poor teaching in the long term can be highly detrimental to students’ future choices, including their subject choices at university (Furstenberg, Kennedy, McCloyd, Rumbaut, & Settersten, 2003; OECD, 2006).

Examining the role of students’ interest in mathematics, McPhan et al. (2008) and Rodd et al. (2010) found secondary school students do believe that studying mathematics increases their level of knowledge and understanding in other disciplines. Students also believe that their confidence and ability to do
mathematics will support their subject choices in their senior secondary years and affect their decisions about university subjects. However, students who regard secondary school mathematics as difficult concede that gaining mathematical knowledge and skills comes at the price of effort, time allocation, and struggle as they need to find a balance between study and personal schedules (Chinnappan et al., 2008; McPhan et al., 2008).

According to Dekker and Malone (1991), policy changes regarding required entry subjects and desired prerequisites for different courses have made mathematics a less likely choice at senior secondary school in some instances, with findings from their survey on transition to tertiary science and mathematics studies showing that the decline in enrolments in advanced level mathematics in secondary schools could be attributed in part to the elimination of some mathematics subjects as university course prerequisites. In a similar vein, Chinnappan et al. (2008) question whether stricter university prerequisites would increase senior secondary mathematics enrolments or just result in a decrease of applications for university courses with such prerequisites. A recent report on the forum Assumed knowledge in maths: Its broader impact on tertiary STEM programs (King & Cattlin, 2014) expressed concern about the effect of universities using “assumed knowledge” rather than an assessment of prerequisites for entry purposes when students do not have the knowledge to make informed judgements about their ability to undertake their chosen degree programs. Universities were urged to review their selection criteria to make sure that necessary mathematical and statistical skills are clearly articulated.

**Career information**

Researchers have found that students who are unaware of career and employment opportunities for science and mathematics graduates tend to decide not to study the subjects even if they are good at mathematics (Chinnappan et al., 2008). In contrast, if students find that their desired future career involves some mathematics they may take the subject with or without having an interest in it. Staples, Bartlo, and Thanheiser (2012) argued that students who choose mathematics to increase their chances of employment would follow their plan
regardless of the number of mathematics subjects that they need to do. Career information may make students think that it is worthwhile to put effort into achieving a great job or interesting career that needs some mathematical skills.

An Australian report based on a major literature review (Tytler et al., 2008) refers to a ten-year longitudinal study by McInnis, Hartley and Anderson (2000), who examined outcomes for graduates with science degrees. It was found that science degrees were an effective means for gaining entry to employment, and science graduates were more likely to be employed than students who only had a major or were more specialised in one branch of science, including mathematics. In addition, according to McInnis et al. (2000), science graduates generally expressed high levels of job satisfaction despite some students’ perception of mathematics graduates as lacking employability.

The Organization for Economic Co-operation and Development Global Science Forum (OECD, 2004) reported that student decisions about study and career paths are primarily based on personal interests in a particular field, and on their insights into job prospects in that field, including incomes and opportunities for promotion (Calkins & Welki, 2006). Similarly, Tytler (2007) claimed the low status of teaching, poor salaries, and a lack of promotional pathways has led to decreased interest among young people in pursuing teaching careers supported by mathematics related degrees. A study into the factors influencing choice of major has found that interest in the subject and expected marketability are among major determinants (Calkins & Welki, 2006). Moreover, lack of information about the applicability of mathematics to everyday life and career opportunities after completing a mathematics degree create another kind of barrier in students’ choice of mathematics at university (Sullivan, McDonough, & Prain, 2005; Tang et al., 2008; Tytler et al., 2008).

**Influence of teachers on students’ self-efficacy**

Bandura (1986) defined self-efficacy as “people’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances” (p. 394). Although self-efficacy is a psychological construct, teachers’ influence of students’ self-efficacy is included here as part of the social
world found within the institution of schooling that potentially influences students’ decisions about subject choice and future participation in education. Research suggests that teachers’ implied messages about the value of learning mathematics, sent verbally and non-verbally in their interactions with students can influence students’ intrinsic motivation that eventuate in their decisions about undertaking the subject (Brigham, Scruggs & Mastropieri, 1992; Cantor, Kester, & Miller, 2000; Patrick, Hisley, Kempler, & College, 2000).

The impact of teachers on students’ interest in mathematics that will guide them towards university courses involving this subject is found in various research studies. Teachers’ participation in students’ educational achievement (Watson, 2003) correlates with their ability to promote a democratic classroom style and practices that endorse teamwork among students (Solomon, Watson, & Battistich, 2002). This means students develop skills including discussing, decision making, and social problem solving (Narvaez, 2006), together with an increase in interest in the subject (Wigfield & Eccles, 1992). This eventually creates situational interest that links to feelings (Schiefele, 1996) and academic choice (Milson & Mehlig, 2002).

In conclusion, the institutional factors influencing the decision to study mathematics at university include government policy and funding programmes that directly or indirectly affect participation in higher education; the provision of career information, academic support, and pathways, admission, and policy advice; and the institutional contributors to students’ achievement and interest in mathematics, such as the quality of teaching during schooling.

### 2.2.3 Psychological factors

Students’ attitudes towards mathematics, their expectations of university mathematics, and perceptions of their own abilities influence their decisions about courses, together with other variables noted above, such as their educational, cultural and socio-economic background, and their access to information about employability after completing their mathematics related courses. Psychological factors discussed in the literature as influencing the choice of mathematics are largely those associated with achievement in mathematics (Hannover & Kessels,
2004), including self-concepts of ability and attitudes towards, and beliefs about, mathematics, including mathematics anxiety. These factors are discussed below.

*Attitudes, beliefs, and mathematics anxiety*

Affective factors such as attitudes, beliefs, and emotions have a vital role in the integration of cognitive factors and can be used to explain students’ behaviours in their mathematics education (Daskalogianni & Simpson, 2001; Ma, 2006). This behaviour will effect students’ tertiary education and consequently their career choices in the future (Lyon, 2004; Lubben, 2010). This is in contrast to the findings of Grootenboer and Hemmings (2007) who claimed that cognitive issues have a greater impact than affective factors in learning mathematics.

Students’ attitudes to studying mathematics varies as it has been found that some students perceive mathematics as hard and useless (Ernest, 1994; McPhan et al., 2008; Tytler, 2007), or the anxiety and learning difficulties they experienced during their previous mathematics study continue at the tertiary level (Dossel, 1993; Crisp et al., 2009). Others are anxious and not sure if they can receive adequate support from the teaching staff if they choose mathematics (Taylor & Morgan, 1999). Dossel (1993), in his extensive research into school mathematics anxiety in pre-service primary school teachers, found that even successful graduates with honours degrees experienced extreme distress at various times when learning mathematics. Some researchers (e.g. Jenkins, Breen, Lindsay, & Brew, 2003) saw mathematics anxiety as more behavioural than cognitive; as an emotional state underpinned by dread and fear (Hembree, 1990).

Mathematics anxiety also manifests itself in students’ choices surrounding mathematics (Dossel, 1993), particularly when the subject’s range and breadth at university is unknown to many school leavers. To combat this, Taylor and Galligan (2002) developed video resources with the primary aim of helping to alleviate the symptoms of anxiety and develop self-confidence, improve problem solving skills and numeracy. Watt (2005) and Rodd et al. (2010), who were similarly concerned with developing students’ higher order thinking and problem solving, and are supported by Williams (2005), McPhan et al. (2008), and Barnes (as cited in Grootenboer & Jorgensen, 2009). The symptoms of anxiety, or conversely interest
in taking science and mathematics that may appear as early as primary school, might be sustained from primary school until the time of transition from secondary school to university (Dossel 1993; OECD, 2003; Tytler et al., 2008). Ikegulu (1998) offered “mathematics phobia” as an appropriate term to define the attitude of unease towards mathematics. He suggested that some individuals’ anxiety outweighs their projection of gains in any educational environment (Duffin & Simpson, 1993; Suthar & Tarmizi, 2010).

While there is a popular view of mathematics as cold, absolute and inhuman, as well as uninteresting, unimportant, irrelevant and hard to understand, researchers have demonstrated that these ideas are clichéd and unhelpful (Allen & Johnston-Wilder, 2004; Ernest, 1994; Masters, 2006, as cited in Tytler et al., 2008).

Rubinstein (2009) related how almost all great human innovations that have changed people’s lives in the last two centuries have involved the triumph of mathematics and, according to his view, the world is increasingly dependent on mathematics. More importantly, the continuation of students’ positive perceptions of mathematics experiences (Ernest, 1994; Burton, 1999) provides a better understanding of the role of mathematicians and mathematics educators in the evolution of science and technology (D’Ambrosio, 2003). Some students already view mathematics as an approach to life, and thinking; they make a strong personal connection between mathematics and their own lives (Petocz, Smith, Wood, & Reid, 2005).

One area of attitudes and beliefs that has received significant research attention is that of self-concept and self-efficacy. Self-concept of ability is one of the areas that have been broadly researched in both individual and social psychology. Baumeister (1999) suggested that self-concept is an individual’s belief about themselves, about their personal values, and their attributes, especially about who and what their “self” is. Self-efficacy and ability were the strongest factors in developing interest in, and choice of, mathematics among 156 college students surveyed by Waller (2006). The option of selecting higher-level mathematics courses under the influence of high self-efficacy was determined by another study investigating transitional tension amongst regional-rural and metropolitan
mathematics students in a teachers’ college, concluding that self-efficacy has a high impact on students’ decision-making (McPhan et al., 2008).

Kleanthous and Williams (2010) investigated students’ dispositions to study mathematics in higher education and the effect of students’ mathematical self-efficacy. They administered a questionnaire to 536 adolescent students in Cyprus. The results indicated that students’ mathematics self-efficacy is an important factor influencing some students’ decision making about future studies in higher education, while students’ mathematics self-efficacy differs across the spectrum from confidence in mathematics to mathematics-phobia. In another study in Ohio, 391 university students provided three types of mathematics self-efficacy judgments: confidence to solve mathematical problems, confidence to succeed in mathematics related courses, and confidence to perform mathematics related tasks. Self-confidence was found to be a stronger predictor in the selection of mathematics related majors than either confidence to solve problems or confidence to perform mathematics related tasks (Pajares & Miller, 1995). Other researchers’ results confirm the importance of self-efficacy (e.g. Tang et al., 2008).

From this discussion, understanding the factors influencing students’ choices of mathematics at university requires further study to gain a better understanding of student motivation and its component theories. James (2002b) asserted that motivational factors associated with higher education are generally unobservable from the outside. Other researchers concur and suggest motivational factors are only experienced through closer study and sustained involvement (Ryan, Koestner, & Deci, 1991). Nonetheless, the need to understand the reasons behind students’ choices of university course and to identify the factors that effect their motivation and choices highlights an important attribute of motivation. Students are moved to act by diverse motivational factors, resulting in highly varied experiences and consequences, leaving researchers to query whether they are motivated because they value an activity or whether there is strong external coercion (Ryan & Deci, 2000). In either case, motivation is not considered a singular construct (Fisher, 1978, as cited in Ryan & Deci, 2000) but the result of numerous factors and stimuli that require closer examination. It is important to answer the question of which
particular motivation is associated with students’ subject choices and how does this unfold?

While there is considerable research on transition from secondary school to university mathematics (e.g. Rubinstein, 2009; Chinnappan et al., 2008; Jordan et al., 2007; Panizzon & Westwell, 2007; Tytler, 2007; Taylor & Morgan, 1999), very little research looks at what motivates students to choose mathematics in the first place (Forgasz, 1998; Holton, 2001). It is important to note that the current study is premised on the belief that students who are motivated to continue their study at a tertiary level and intend to take a mathematics course sometimes, as Holton (2001) points out, confront barriers built and hardened during their past study experience (Surry, 2006). As discussed in the above sections, these include social, institutional and psychological barriers.

The next section provides an overview of theories of motivation as a means of understanding why students might choose to study mathematics at university.

2.3 Theories of motivation

Contemporary theories of motivation that consider the interactions between cognition, affect, and behaviour provide powerful explanations for educational decision making. The explanatory power of such theories in relation to decision making more generally, and educational choices more specifically, has been discussed above in relation to literature that specifically focuses on psychological constructs, but also in relation to literature on social factors, where psychological factors such as self-confidence and self-concept are seen to interact with social background variables such as socio-economic background (e.g. Pajares & Miller, 1995; McConney & Perry, 2010). This section provides a review of theories of motivation that were considered as potentially informing this study, including the design of instruments and the analysis of data. The discussion that follows includes a definition of motivation, and a discussion of the distinction between intrinsic and extrinsic motivation, choice theory, and the Expectancy Value Theory of Motivation.
2.3.1 Definition of motivation

Motivation can be seen as the inner power or energy (Kevin, 2009; Yeager, 2005) that is fuelled, inspired and instigated (Sasson, 2004; Velez, 2007) by a set of causes, such as desire and ambition, that pushes one in a direction to perform a certain action (Martin & Marsh, 2003; Ryan & Deci, 2000; Sasson, 2004). It is a search for determination (Weiner, 1992) or a stimulus that induces one to act in a particular way that relates to circumstances indicated by facts (Berriman, Leslie, & Carlson, 2004). Educators define the study of motivation as the determinants of human and animal activity (Young, 1961).

The massive increase in discussions around the term “motivation” that can be seen in the fields of education, psychology, management, and many more highlights the need to develop the definition of the term (Higgins & Kruglanski, 2000; Ryan & Deci, 2000).

Mook (1987 as cited in Weiner, 1992) expands this definition to include the search for principles that will help to understand why people or animals initiate, choose, or persist in a specific action in specific circumstances. However Weiner (1992), in his third book on motivation, highlights the importance of emotions and feelings, marking a shift from early motivational psychology, which was more concerned with observation, action, and activation (Weiner, 1992). Contemporary motivation theory is more interested in choice, judgment, and emotional feelings (Zeelenberg, Nelissen, Breugelmans, & Pieters, 2008). Ryan and Deci (2000) found that the power of direction and persistence produces motivational energy that is popularly known as affection and described by Wiener (1992) as the power of feeling and judgment. For example, the power of direction in students’ course selection could arise from the promise of a future career, stimulating students’ motivation to select a particular university course harmonising this with a desired future career.

Weiner (1992) believes the motivational question is “Why?” as in “Why is he learning?” rather than “How is he learning?” For this study, the questions are: Why did the student choose mathematics? How did this happen? And, what made it happen?
To understand why students study mathematics at university, there is a need to explore the full range of students’ motives as they make their decisions. This exploration must consider the influential factors affecting the full decision-making process that students go through (Feagin, Orum, & Sjoberg, 1991). Yet, students are also influenced and motivated by less direct motives like their experiences as students, as well as their educational, socio-economic and cultural backgrounds (Marks et al., 2001). Motivation under any circumstance is fuelled by energy and persistence (Ryan & Deci, 2000). The same occurs when choosing particular courses and subjects. Research relating to students’ decisions to pursue a university education relating to choice of subjects was reviewed above. In this section theories of motivation are reviewed as part of the search for theoretical frameworks that might inform the current study and the analysis of data.

A definition of the term “motivation” needs to acknowledge the distinction between individual and social views of motivation, as individual and social factors can result in different type of motivations. One interpretation of individual motivation (Ryan, Connell, & Deci, 1985) suggests that internalised motivation occurs when people learn about the value of certain behaviours in their society, causing them to eventually act in a way consistent with these values (Ryan et al., 1985). For example, students may be motivated to choose particular subjects and areas of study having come to desire a career valued by society (Heiat et al., 2007), parents (Ma, 2009; Schagen & Hodgen, 2009) and other influential parties, in preference to their own personal interests and desires. This discussion will be expanded to include a classification of intrinsic and extrinsic motivation.

### 2.3.2 Internal (intrinsic) and external (extrinsic) motivation

Motivation can be classified by an analysis of its outcome (Rudd, 2005), which in the literature has led to the development of two distinct categories known as intrinsic and extrinsic motivation. Internal or intrinsic motivation is produced by power focused on inherent satisfaction that entails challenges toward aims that do not produce an external return. External or extrinsic motivation is engendered by power directed from expecting rewards and congratulations by others in response
to success (Deci, 1975; Schinnerer, 2007). It accomplishes and completes a strong reinforcement learnt solely to satisfy internal motivation (Marshal & Mac Hardy, 2008; Ryan et al., 1991) where attaining a reward could be aspired intrinsically. Success might refer to what students expect to achieve by doing a particular course for a high mark in terms of gaining the approval of others or obtaining a better career in the future that reinforces their choice of a subject or course at university. Through the theory of engagement (Martin & Munns, 2005), different types of extrinsic and intrinsic motivation (Ryan & Deci, 2000) can be compared to identify the most significant factors influencing students’ choice of subjects.

Whether a person behaves in a specific way out of their own interests and values or does it for reasons external to them would be a matter of significance in any culture and signifies a basic dimension by which people make sense of their own and others' behaviours (Carden, 2007; Ryan & Connell, 1989 as cited in Ryan & Deci, 2000).

Sometimes an internal or intrinsic emotion like anger or happiness is used as a motivation for its own sake (Hayamizu, 1997; Ryan & Deci, 2000) without any expectation of external rewards (Deci et al., 1991); this is what students receive in response to making choices based on their own interests and desires. External or extrinsic motivation, however, depends on external reasons for behaviour that exist outside of the person, such as rewards or coercion (Schinnerer, 2007). This could impact on students’ subject selection processes, where they are influenced by the outcome of their internal motivation, resulting from a positive experience of secondary school mathematics bringing about a particular interest in the subject, or a negative experience leading to mathematics anxiety. Both examples result in students making a subject selection based on their own interests. Alternatively, students might choose courses in response to strong external forces like family background, job availability, competitive admission processes, a lack of understanding of the role of mathematics in society, or the need for an immediate income. These external forces may conflict with intrinsic motivation towards mathematical studies.
2.3.3 Choice Theory

Choice Theory, developed by William Glasser, argues that people are internally but not externally motivated. The genetic structure of every human being, according to Glasser (1998), tends to set a favourite pattern that seeks to fulfil certain needs. These basic needs are similar to Maslow’s (1971): to be loving and connected to others (belongingness and love); to achieve a sense of competence and personal power (esteem); to act with a degree of freedom and autonomy; to experience joy and fun; and to survive (psychological need). These needs integrate a range of phenomena and allow one to specify the contextual conditions that will facilitate motivation, performance, and development (Deci & Flaste, 1996; Higgins & Kruglanski, 2000; James & Jeffry, 1996). For example, one might choose mathematics to earn a greater income or to gain social prestige by the possession of higher knowledge at the expense of individualism.

The major concept in choice theory is the notion that people always have some choice about their behaviours. This does not mean that the choices are unlimited or that information received from outside is irrelevant to the kind of behaviour is chosen. It means that the amount of control and responsibility for choices is more than some people might believe (Glasser, 1998; Nelson, 2002; Allison & Cossette, 2007).

Humans, knowingly or not, constantly compare their perception of the world with how they would like it to be, and determine that their current behaviour is the best available choice to take them in the direction they want to go. When people are taught to self-evaluate their choices they have the best chance of achieving what they want in ways that are responsible (Super, 1990; Glasser, 1998). In his contributions to career development, Super (1990) emphasised the importance of the development of self-concept. He claimed that self-concept changes over time, and develops as a result of experience. Choice theory in psychology explains why and how people make choices that determine the course of their lives (Glasser, 1998; Higgins & Kruglanski, 2000). While there may be a strong relationship between peoples’ choices and their plans, some make decisions not based on previous preparation and aspirations and are forced to take action on things to
which they are uncommitted (Cohen & Levesque, 1990). Similarly, students also might change direction and choose other courses or subjects for study even after being motivated towards doing mathematics at university, or drop other subjects in favour of mathematics without any prior long-term plan. Figure 2.2 shows three conditions – inspired by Glasser’s theory – that may help understand how a decision can be shaped and built.

![Choice Paradigm](image)

*Figure 2.2. Choice Paradigm based on Glasser (1998).*

The three components of decision making identified in Glasser’s choice paradigm are discussed below.

1. *Theory of Competence and Self-efficacy.* Self-efficacy, the first element of psychological need, is peoples’ beliefs about their capabilities to produce effects (Bandura, 1994; Schunk & Pajares, 2000). Bandura (1994) presented four main sources of influence in the development of a person’s beliefs about their own efficacy. He argued that the first and most important factor is mastery of experiences where successes build a strong belief in one’s personal efficacy and failures undermine it, especially if this happens before the establishment of a firm sense of efficacy. Creating a robust sense of efficacy is therefore achieved through the mastery of experiences. Witnessing explicit experiences provided by social models or standards is second; beliefs in possessing capabilities is third, and
reducing stressful reactions to failure is the fourth way of creating and strengthening self-efficacy.

In the context of this study, self-efficacy is students’ beliefs about their capacity to overcome challenges related to certain levels of success in mathematics that is part of their university course. Students with higher self-efficacy are more committed and determined to achieve the goals they set for themselves (Higgins & Kruglanski, 2000; McPhan et al., 2008; Waller, 2006). Self-efficacy and a belief in one’s own competence enhance motivation and engagement in an environment offering autonomous choice (Bandura, 1994; Lent & Hackett, 1987). Elliot and Dweck (1997) emphasised the ways in which achievement is motivated by the desire to experience competence and avoid experiencing incompetence. Further, Bandura (1994) asserted that, among the mechanisms of personal agency, peoples’ beliefs about their capabilities to control events that affect their lives are both central and pervasive. Relatedness to others’ thoughts and feelings, the second part of psychological needs, is next.

2. Relatedness to others’ thoughts and feelings. Another feature of psychological need that plays a part in decision making is setting up and generating bonds between one’s own goals and others’ thoughts and feelings (Ryan & Deci, 2000). Individuals are usually sensitive to the thoughts and feelings of others when establishing and maintaining successful social relationships (Acker-Ball, 2007; Baumeister & Leary, 1995; Ryan & Deci, 2000) and this plays a part in decision-making.

Students whose external motivation is influenced by their parents’ expectation that they study mathematics can be concerned especially with social connectedness; such students have a high need to be attentive to and accurate in absorbing social codes and systems (Awad, 2008; Leary, 2001; Miller, 2010; Werfhorst et al., 2003). It is presumed that the strong need for social acceptance is an adaptation that evolved because it prompted survival and production among human and prehuman ancestors (Ainsworth, 1989; Barash, 1977; Baumeister & Leary, 1995).

3. Autonomy. Dworkin (1998) noted “[a] certain ideal of the person is the cornerstone of his moral edifice, a central notion of that idea is the notion of
autonomy” (p. 3). Anderson (2008), who supports Dworkin’s idea, believes people contribute to their own oppression because irrational roots of self-undermining choices interplay between human nature, social structures, and cultural beliefs (Anderson, 2008). Bandura (1986) defines self-efficacy as “people’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances” (p. 394).

According to a large body of experimental research in social psychology, autonomy – “feeling free and volitional in one’s actions” (Deci, 1995, p. 2) – is a basic human need. Autonomy plays an important role in the socio-cultural theory of learning, especially where the motivation of making a choice is linked to an autonomous decision of the choice maker (Carter, 2004).

Black and Deci (2000) examined self-regulation in the choice of university course of students in an organic chemistry college-level course. They showed relatively more autonomous reasons (versus controlled reasons) for choosing their particular courses and Black and Deci found enjoyment and low anxiety were accurate predictors of higher interest with change in autonomous self-regulation in turn predicted a change in students' performance. Black and Deci’s findings are supported by other researchers (Brown, Brown, & Bibby, 2008; Lyon & Quinn, 2007; Steinberg, Birkett, & Smith, 2007; Tsagala & Kordaki, 2007). In addition, students' perceptions of their instructor’s autonomy was predicted in their autonomous action (Higgins & Kruglanski, 2000; McPhan et al., 2008; Ryan et al., 1991).

Cognitive theories of motivation and concepts discussed above, such as intrinsic and extrinsic motivation, and self-concept and self-efficacy, provide very useful frameworks for analysing students’ decisions in relation to studying mathematics.

The next section provides an overview of the Expectancy Value Theory of Motivation, a contemporary theory that has been taken up in many studies in a wide range of contexts and which brings together notions of self-concept, self-efficacy and intrinsic and extrinsic value.
2.3.4 Expectancy Value Theory of Motivation

Between 1980 and the early 2000s Eccles and her colleagues worked on a hypothesis linking achievement-related choices to individual’s expectations for success, and connected individual’s values to a range of available options considered by the individuals themselves (Eccles, Wigfield & Schiefele, 1998). They argued that beliefs about expectancy and value – referred to as achievement-related beliefs – are related to cultural norms, experiences and aptitudes. These beliefs, and related outcomes and goals, are related to an individual’s attribution patterns, input from significant others, perceptions of gender roles, self-perceptions and perceptions of the task (Eccles et al., 1998). They particularly correlated achievement-related activities to goals (Eccles, 2009a). This framework draws upon concepts included in the theories already discussed, such as the distinction between intrinsic and extrinsic motivation, the concept of self-efficacy and expectation of success, as well as accounting for social background variables such as ethnicity.

The hypothesis of Eccles et al. (1998) was based on two questions: (1) Can I do the task?; and (2) Do I want to do the task? In relation to the second question, they then established four constructs for school work: (1) enjoyment that relates to intrinsic interest; (2) consistency in pursuing the task arising from self-image or identity that relates to attainment value; (3) external reward of valuing a task in facilitating long range goals that relates to utility value; and (4) perceived cost of engaging in activity that relates to cost value (Eccles, 2009a). The expectancy value theory posits that both expectation of success (I can do it) and value (I want to do it because ...) are required for a student to be motivated to pursue a task.

Eccles et al. (1998, p. 8) related these beliefs to “cultural norms, experiences, aptitudes, and to personal beliefs and attitudes that are commonly assumed to be associated with achievement-related activities”. Eccles then focused on the role of personal and collective identities in motivating actions that will influence expectations of success. Figure 2.3 represents their expectancy value model. The arrow includes the effects of an individual’s choices on subsequent behaviours.
In relation to this model, Eccles (2009b) noted that:

The number of items within several of the boxes are just examples. Boxes represent large categories of constructs at the same theoretical level. Causal influences are assumed to go predominantly from left to right. By and large, constructs within a column influence each other reciprocally. Since the models play out over time one arrow is included to illustrate the fact that today’s choices become part of tomorrow’s history of experience (p. 80).

As Guthrie, Wigfield, and Perencevich (2004) claimed, motivation and engagement work are driving forces on students’ learning and ultimately their quality of life during adolescence to guide them in pursuing further education or participating in labour market opportunities. Wigfield, Eccles, Schiefele, Roeser, and Davis-Kean (2006) suggested that substantial individual differences in self-representation are related to patterns of motivation arising from early childhood onwards and differences are associated with variations in the readiness to learn. This highlights the importance of distinguishing types of school motivation towards particular school subjects in the early primary school years (Guay, Chanal, Ratelle, Marsh, Larose, & Boivin, 2010). Individuals identify with the reasons behind their behaviour. Their behaviour therefore is performed “because it is part of who the
person is” (Guay, et al., 2010, p. 713). A person thus is identified by the importance of a behaviour and “reciprocally assimilates that identification with other aspects of the coherent sense of self” (Guay, et al., 2010, p. 713).

### 2.3.5 Rationale for choosing the Expectancy Value Theory of Motivation as the study’s framework

Existing literature on motivation and choice suggest that an understanding about motivational theories concerning both cognitive and affective issues that initiate and direct individual’s values, expectations and emotions is necessary (Schunk & Pajares, 2002). This theory “is one of the most important views on the nature of achievement motivation” (Wigfield, 1994, p. 49), building on and integrating earlier theories from 1957 by Atkinson, followed by Battle in 1965-66, and then in 1969 Grandall, who added more to the argument, until 1982-1992 when Feather engaged with the hypothesis (Wigfield, 1994). Their long and enormous research in the field, which examined students’ abilities in making academic decisions by evaluating their expectation of success and their values, has been used by other researchers to investigate STEM students at the post-school level (Schunk & Pajares, 2002). The *Expectancy Value Theory of Motivation* developed by Eccles and Wigfield (Eccles & Wigfield, 1995, 2002; Wigfield, Tonks, & Klauda, 2009) is a highly influential explanatory theory that brings together earlier concepts in relation to factors and variables influencing behavior and decision-making. The theory explains *expectation of success* and perceived *task value* as functions of previously developed domains such as cultural background, individual beliefs, personal experiences and characteristics. Perceived task value builds on previous conceptions of different sources and types of motivation. In this way, the relationship between these two constructs allows for a nuanced understanding of decision-making behaviours. It provides a robust framework for this study by providing a conceptual tool for understanding the diverse reasons that undergraduate mathematics students give to explain their current educational status. This study has used the *Expectancy Value Theory of Motivation* as a
theoretical framework to analyse participants’ qualitative accounts of their
decisions to pursue mathematical studies at university.

2.4 Positioning of the study in the context of existing
literature

Existing literature suggests there is considerable research on transition from
secondary school to university mathematics (e.g. Rubinstein, 2009; Chinnappan et
al., 2008; Jordan et al., 2007; Panizzon & Westwell, 2007; Tytler, 2007; Taylor &
Morgan, 1999), but very little research looks at what motivates students to choose
mathematics in the first place (Forgasz, 1998; Holton, 2001). The significance of this
study is its interest in investigating students who are “interested” or “have chosen”
mathematics (examined previously by Lyon, 2004; Panizzon & Westwell, 2009) in
contrast to much research (e.g. Marks et al., 2001; Forgasz, 2004; McPhan et al.,
2008; Chinnappan et al., 2008) that has pointed out obstacles on the way to
undertaking the subject in higher education. Others have examined the role of
attitude (Holton, 2001; Khoo & Ainley, 2005; Hannula et al., 2007) related to
achievement and affective outcomes. This thesis focuses on the reported views,
experiences, and decisions of current undergraduate mathematics students as they
reflect on their decision making, how they came to be enrolled in their courses, and
what they perceive to influence their decision to study mathematics.

There are works in the same area that were developed many years ago,
focusing on gender, nationality, or differences in social status (Dekker & Malone,
1991; Dossel, 1993; Forgasz 1996, 1998). Other similar Australian works have
focused on the choice of mathematics at secondary school (Awad, 2008; McPhan et
al., 2008, Barnes, 2000; Tytler et al., 2008), high achieving students (Lyon, 2004),
and tertiary entrance performance (Fullarton, 2002; Marks et al., 2001; James,
2000). This means that the factors and variables that influence first year
mathematics students’ decisions to enrol in their programs have not been given
significant attention yet compared to other groups of students. There are studies
that pursued the same aims in other academic fields such as accounting (Heiat et
al., 2007), physics (Lyon, 2004), economics (Worthington & Higgs, 2004), IT (McInerney et al., 2006), and biology (Smyth & Hannan, 2006).

Collecting data from students’ own words to explore the phenomenon in addition to quantifiable information may be one of this study’s distinctive characteristics, as much of the existing literature is based only on quantitative participation data or attitudinal scales.

This study may in addition fills a gap in research on factors influencing students’ choice of mathematics at university in Australia and may be added to similar works conducted in other places – for example, England (Williams et al., 2007), USA (McInerney et al., 2006), America (Agajanian, Morgan & Timpson., 2008; Simpkins et al., 2006), Nigeria (Salami, 2007), Malaysia (Suthar & Tarmizi, 2010), Germany (Schnabel et al., 2002), Greece (Tsagala & Kordaki, 2007), and New Zealand (Hipkins et al., 2006).
CHAPTER 3  METHODOLOGY

The previous chapter discussed the literature on relevant theories and the findings from empirical studies regarding the phenomenon of factors influencing students’ choice of mathematics at university. The literature review identified Eccles’ *Expectancy Value Theory of Motivation* (Eccles et al 1998; Eccles, 2005, 2009a) as a suitable framework to analyse students’ reflections on their educational decision making. This chapter discusses various research paradigms, methods and methodology and justifies the choices made for in this study.

### 3.1 Research paradigms

Research design emerges from a paradigm or world view, that is ontology, held by the researcher. Kuhn (1962) warned that each paradigm will satisfy only those criteria determined for itself and will fall short of some of those that are dictated by its challengers, and, as a result, no paradigm ever solves all the problems it defines. According to Kuhn, paradigms are not derived from a common standard, and thus may lack the potential to be compared to any other paradigm (Blaxter, Hughes, & Tight, 2001; Corbin & Strauss 2008). A research paradigm is “a broad view or perspective of something” (Taylor, Kermode, & Roberts, 2007, p. 5). Guba (1990) proposed four possible paradigms that may provide an appropriate structure for research: scientific/positivism, post-positivism, critical theory, and constructivism.

#### 3.1.1 Positivism

Scientific or positivist theories seek to tell the true nature of reality (Teddlie, & Tashakkori, 2009). In the scientific view, theory and quantified inquiry form the paradigms that are the researchers’ concerns, especially of what is to be observed, the type of questions necessary to obtain the required data and how they should be constructed, and how the results from the investigation should be analysed (Lakatos & Musgrave, 1970). Kuhn (1962) described the scientific paradigm as recognising that, as knowledge builds, concepts change, and paradigms evolve.
Howard, McMillen, and Pollio (2002) discussed the evolution of educational research, including the widespread availability of electronic bibliographic databases, improved indexing services, systematic reviews, and evidence-based practice guidelines, which have led to an increase in the acceptance of research findings and recommendations by practising educators.

Guba (1990) described scientific/positivist ontology as a realist perspective, with permanent natural laws and paths. The positivist paradigm claims that knowledge is only derived from observation, experience, and verification resulting from quantitative research method. Positivists relate their paradigm to the traditional stance claiming that scientific knowledge can be acquired only by empirical processes not by argument. Research should be observable and repeatable and data collection should be informed by hypotheses, statistical modelling and evaluation (Hawkesworth, 1988). Knowledge is formed from generalisations removed from time and context, and thus can form laws of cause and effect. The epistemology described by Guba is dualist/objectivist, which maintains a non-interventionist view that removes values and bias from influencing outcomes. The research method for this paradigm is based on questions or hypotheses that are subject to rigorous testing under controlled conditions, that is, a quantitative approach.

3.1.2 Post-positivism

Karl Popper (2002), a post-positivist, rejected the positivist /scientific model arguing that neither the logic of induction that uses past results to forecast future events, nor replication and verification of research findings could guarantee the truth that is knowledge. Popper viewed positivism as a paradigm lacking connection between scientific truths of the past, such as research findings, and future events. Popper challenged the positivist notion of a passive observer, stating that the researcher was an active participant in the research process who gathers and interprets data and also uses their imagination to lead to the findings of the study. Lastly, Popper challenged the observation, experience, or verification paradigm for knowledge, claiming that “scientific discovery commences with, and proceeds from,
theory” (cited in Hawkesworth, 1988, p. 42). Popper argued that deductive logic was central to scientific analysis and was the basis for theorising.

Guba (1990) portrayed the ontology of anti-positivism or post-positivism as critical realism, believing in the existence of a real world and that perceiving it is not possible for imperfect human beings (Cook & Campbell, 1979; Denzin & Lincoln, 1994). In this way, an investigation could proceed within the research field’s discipline and its findings could contribute to the body of knowledge through publication in peer-reviewed journals (Clark, 1998). This stance was broadly accepted and adopted by educational researchers, such as Burbules and Linn (1991), Fien (2002), and Thomas (1997), but was disputed by others such as Connell (1997) who argued that a post-positivist paradigm was “scholarship that makes its biases part of the argument” (Lather, 1986, p. 259). Post-positivists, in advocating methodological pluralism, suggest that the type of approaches in a specific study should be based on the questions that are addressed by the study.

The ontology of post-positivism is critical realist (Guba, 1990). Critical realism is a philosophical perspective that brings a realist ontology and relativist epistemology together to construct a strong form of relativism (Guba, 1990). Guba asserted that the natural law of external reality can never be fully comprehended. The objectivist epistemology is modified in that reality and remains the ideal and the research method is experimental/ manipulative. A qualitative suite of approaches to research in more natural settings, using qualitative methods, is implemented, reintroducing discovery into the research process. However the epistemology can only be approximated and this lack of rigour is supplemented by review by the critical community. Guba (1990) found the label of critical theory inadequate for all alternatives of the category for this paradigm: “ideologically oriented inquiry that includes: neo-Marxism, materialism, feminism, Freireism, participatory inquiry and other similar movements as well as critical theory itself” (p. 23).
3.1.3 Critical theory

Critical theory is described by Habermas (1981), who stated that connections between knowledge and human interests develop through linguistic communication rather than either positivism or the more qualitative post-positivist approach. However Guba (1990) labelled this paradigm “ideologically oriented inquiry” (p. 23), reflecting the values of the scholars who were united only by their rejection of a value-free research paradigm. Lather (1986) was concerned with the methodological implications of critical theory, and established a position of “research as praxis” to advance knowledge. Lather sought “a democratised process of inquiry characterised by negotiation, reciprocity, and empowerment – research as praxis” (p. 257) such as submitting a draft of a paper to a research participant to develop negotiation and reciprocal discussion.

In higher education, Barnett (1997) posited that, using this theory, students could critically evaluate knowledge, and develop critical self-reflection and critical action as “a form of social and personal epistemology; the belief that through higher education students can be changed as persons by their experiences” (Barnett, 1997, abstract). Barnett advocated critical thinking as appropriate for a learning society.

The ontology of critical paradigm is similar to post-positivist ontology – the critical realist and its subjectivist epistemology mediates the outcome of research (Guba, 1990). The research method for critical theory is dialogic and transformative as subjectivity in texts helps to ensure clarity (Sullivan, 2011). The researcher becomes interpretive by using language with the dialogical method assisting analysis due to a variety of contextual discussions and dialogues that need to be understood (Sullivan, 2011). On the other hand, Mertens (2010) suggested that it is a transformative paradigm with mixed method approaches as “its associated philosophical assumption indicates inequality [in societies with] culturally complex settings [and that this can provide a basis for social change because it contains the] potential strength of combining qualitative and quantitative methods” (Mertens, 2010, p. 9).
3.1.4 Constructivism

Constructivism as a theory of learning (Hiebert, & Carpenter, 1992) drew on the work of Kant (1881-1966, cited at Ponterotto, 2005). Kant argued that human perception derives from both evidence of the senses and the mental apparatus that organises the incoming sense impressions. For Kant, a human’s claims about nature cannot be independent of inside-the-head processes of knowing a subject. Kant highlighted a central tenet of constructivist thinking, namely that reality is constructed by the individual (e.g. the research participant). This idea was reformed by Jean Paul Sartre (1905–1980) who proposed the theory of existentialism and developed the phenomenology that disputes the concept of “groundlessness” and the idea of radical freedom, that is “the interplay of the structuring consciousness and its free transcending of structures” (Howells, 1992, p.37). This philosophy has been supported by many researchers, including Patton (2002).

Constructivism involves a range of psychological theories that suggest learning involves mental construction, which is an active process that occurs in an individual’s mind (Swan, 2005). The analysis of data in a constructivist approach aims towards consensus, as “over time, everyone formulates more informed and sophisticated constructions and becomes more aware of the content and meaning of competing constructions where the advocacy of activism is also a key concept in this view” (Guba & Lincoln, 1994, p. 113). However, this social construction of knowledge between the researcher and a study’s participants is based on the researcher’s viewpoint, and thus is open to bias (Healy & Perry, 2000). Collection and interpretation of data in a constructivist research paradigm is a collective, not an individual, process. Researchers should therefore consider their own assumptions, the social norms that prevail in an interview or focus group, and the socially constructed meanings that influence the outcome of the interview (Crotty, 1998). In Guba’s (1990) summation, the ontology of constructivism is relativist: multiple individual and social constructions form realities, which are dependent on the individuals and the context in which realities are constructed. The constructivist paradigm is therefore subjectivist, where the inquirer and the study participants are created by the study itself. The research method is interpretive (hermeneutic) and
argument-based (dialectic): “individual constructions are elicited and refined hermeneutically, and compared and contrasted dialectically, with the aim of generating one (or a few) construction where there is substantial consensus” (Guba, 1990, p. 27). Constructivist research methods include quantitative, qualitative, or mixed methods, which are triangulated (see Section 3.2).

3.1.5 Choice of a research paradigm

In summary, the “paradigm wars” of the 20th century emerged in an environment in which social scientists adopted concepts from the mathematical and physical world scientists (Gage, 1989). In the scientific/positivist paradigm of Kuhn (1962), the research process derives its results from statistical analysis. This paradigm is based on the premise that knowledge is derived from observation and verification of results, thus its research method is empirical, not dialectic (Hawkesworth, 1988). Post-positivists, including Popper (2002), employ an “approximate” approach, recognising those aspects of knowledge that could not be fully achieved, with research findings accessed through peer-reviewed journals (Clark, 1998). Critical theory is developed through connections between knowledge and human interests via linguistic communication and the acquisition of knowledge is advanced through peer review (Habermas, 1981). However this means that it is based on values and argument and its constructs therefore lacked consensus. Constructivism addressed this dilemma, as the paradigm emphasised the social construction of knowledge between the researcher and study’s participants (Guba & Lincoln, 1994). They argued that possible bias can be averted through mixed method research and triangulation. These paradigms are presented in Table 3.1 based on their ontology, epistemology and research methodology.
Table 3.1
*Summary of research paradigms* (Source: Guba, 1990, pp. 20–27).

<table>
<thead>
<tr>
<th>Paradigm</th>
<th>Ontology</th>
<th>Epistemology</th>
<th>Research method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific/positivist</td>
<td>Realist</td>
<td>Dualist/objectivist</td>
<td>Experimental/manipulative</td>
</tr>
<tr>
<td>Post-positivist</td>
<td>Critical</td>
<td>Modified</td>
<td>Modified experimental/manipulative</td>
</tr>
<tr>
<td>Critical theory</td>
<td>Critical</td>
<td>Subjectivist</td>
<td>Dialogic and transformative</td>
</tr>
<tr>
<td>Constructivist</td>
<td>Relativist</td>
<td>Subjectivist</td>
<td>Hermeneutic and dialectic</td>
</tr>
</tbody>
</table>

The study is based on ontological assumptions about the constructed nature of reality and epistemological assumptions about what we might know about reality – that is, that we can only access subjective views. Subjective views are key to conceptualisations of motivation that are drawn upon in this study, where individuals’ perceptions, beliefs and subjective experiences are seen as the basis of decision making. This research is positioned within a constructivist research paradigm because the research question calls for the personal opinions of the participants related to their choice of mathematics at university. These opinions are constructed from the participants’ individual life experiences, including their feelings, actions, and the value they place on mathematics. There is no “correct” reason for choosing mathematics at university – i.e. no objective reality. The researcher begins with no preconceived ideas of a possible “correct” reason or hypothesis, rather she seeks to reveal the perceptions held by the participants. The researcher’s final theorising is founded on the participants’ opinions. Starting from these ontological and epistemological assumptions, this study applies a mix of both quantitative and qualitative methods in order to collect data on participants’ subjective views.

### 3.2 Research methods

After determining the methodological approach, the methods for identifying and collecting the appropriate data must be decided. A method, by definition, is a
set of procedures and techniques for gathering and analysing data and relates to the data collection instruments (Blaxter et al., 2001; Corbin & Strauss, 2008). Choosing a research method depends on the research question, the nature of the answer required and the data that is needed to be collected. The next section discusses appropriate types of data, followed by a discussion of different methods used in collecting data.

### 3.2.1 Types of data

*Quantitative* data are presented in numerical form and can be quantified and analysed statistically (Bryman, 2004). Methods that collect numerical data and frequencies are quantitative methods – for example, surveys, tests, and experiments that generate numerical measure or scores. *Qualitative* data, on the other hand gather non-numerical and expressive data rich, meaningful, varied in character, and difficult to obtain through quantitative methods (Miller & Crabtree, 1994). Its primary purpose is to determine and analyse causes and effects (Miller & Crabtree, 1994) and data are collected mostly through interviews and observations. One criticism of this type of method is that it can lack the validity and reliability of quantitative methods. Nevertheless, because of their differences, quantitative and qualitative data do complement each other and many researchers use both methods in a mixed method approach (Teddlie & Tashakkori, 2009).

### 3.2.2 Quantitative approaches and quantitative analysis

Quantitative research, according to Muijs (2011), is a method of collecting numeric data that is analysed using mathematical methods. As a result, because relatively few phenomena in the field of education are in this form, this method is not used extensively for research in the area. This said, in reality *quantitative analysis* is not limited solely to numeric data. Data may be collected qualitatively, perhaps through a Likert scale, and assigned numeric values for quantitative analysis. In addition, counts on qualitative data, for example affective factors such as attitudes, can be produced and analysed by a statistical tool, such as a chi-square test.
Research questions for which quantitative data collection is suitable include those requiring a quantitative answer, such as demographic totals. Another situation is where change occurs; that is, whether totals are increasing or decreasing – for example when asking whether more or fewer students are taking mathematics courses. A third instance where a quantitative approach would be appropriate is in predicting scores on one variable, for example the number of students taking mathematics courses (Muijs, 2011).

The method uses a positivist paradigm as an objective view of social reality that looks for the true nature of reality. The three concepts that underpin quantitative research are validity, reliability, and generalisability (Muijs, 2011). These have implications for the identification of research participants or sampling. Validity, reliability, and generalisability are discussed below as the criteria for rigour in quantitative research. This is followed by a presentation of quantitative sampling approaches.

**Validity in quantitative research**

_Criterion validity_ has two forms: predictive and concurrent. Predictive validity refers to the ability of the research question to predict a relevant outcome, while concurrent validity is a measure of how well a particular test correlates with a previously validated measure (Muijs, 2011).

_Content validity_ is used to verify the validity of survey or test items to capture the desired content. It refers to the ability of the instrument to probe all aspects of the social construct being investigated. Haynes, Richard and Kubany (1995) described it as “the degree to which elements of an assessment instrument are relevant to and representative of the targeted construct” (p. 238).

_Construct validity_ determines whether the measure of a construct is related to other constructs in the questionnaire with which it is theoretically associated. Construct validity differs from criterion validity as it refers to the relationships between theoretically related constructs, not between two measures of the same construct (Terre, Blanche, Durrheim, & Painter, 2004). These authors explain that if a construct has content validity, it is more likely to be related to other measures of the same construct (criterion-related validity) and is more likely to be related in
theoretically predictable ways to other associated constructs (construct validity) (p. 151).

Mindful of the concerns of Galasiński and Kozłowska (2010), it is necessary that survey questions be coherent and measurable, and that these measures can be theoretically aligned with those from other constructs within the survey.

**Reliability in quantitative research**

Reliability of quantitative data, according to Punch (2005), is consistency of measurement over time – that is, its test-retest reliability through successive tests of the same instrument, and its internal consistency within indicators, such as Cronbach’s (1951) coefficient alpha. The two measures, test-retest reliability and coefficient alpha, can be used to estimate reliability of a measuring instrument. Because of limitations with statistical reliability, Punch (2005) advocated a validation strategy that includes both qualitative and quantitative methods.

**Generalisability in quantitative research**

Generalisability of results obtained from quantitative data is the extent to which the results from the sample data can be extended to the population that is being tested. Onwuegbuzie and Collins (2007) stated that quantitative researchers typically draw inferences from the statistical representativeness of the sample.

**Sampling**

Research questions are usually first proposed and then the research is designed to elicit appropriate data to collect and analyse (Ott & Longnecker, 2010) but selection of the research respondents is crucial for data collection, and this can involve several approaches. Babbie (2010) suggests that random sampling, based on probability theory, is most widely used in social research, although in many instances it is not relevant to the research question. Probability sampling typically involves some form of random sampling method such as: simple random sampling; systematic sampling; stratified sampling; probability proportional to size sampling; and cluster sampling. Simple random sampling is described by Berger and Zhang
(2005) as a means of allocating the same probability of inclusion to each independent person (or unit) in the population.

Thus, each sample consisting of the same number of people has the same probability of becoming the selected sample. Systematic sampling imposes a system on random sampling, such as taking every tenth name from a list of the study participants (Denscombe, 2007). Stratified sampling is a system by which every member of a population has a chance of being selected within their representative proportion in the total population, such as all relevant categories of gender and age (Denscombe, 2007). Probability proportional to size (PPS) sampling can improve accuracy for a smaller sample by concentrating on the proportions of the population that have the largest impact on the research questions (Sudman & Kalton, 1986). Cluster sampling, according to Teddlie and Yu (2007), uses groups within a population, such as schools, hospitals or clubs.

Of the non-probability sampling methods Babbie (2010) argued that reliance on available subjects is perhaps the most difficult to justify, as it cannot be generalised into the target population. An instance of this is sampling all students from one large course, then attempting to generalise into the whole student population. Therefore, purposive sampling is based on the researcher’s judgement of which respondents to the study are most representative of the population relevant to the research question. Quota sampling is another method of dividing the population by some characteristic such as income or place of residence to ensure that a number of random samples are obtained from each group. The final sampling method is snowballing, where social networks of respondents encountered generally in qualitative sampling are used by the researcher to gather further participants.

The data-gathering instrument should collect measures, such as demographic data, or indicators, where comparison measurements can be made using a series of questions that for a quantitative study are usually administered through a self-completed questionnaire. Questions could concern attitudes, social situations, or behaviour. In gathering such data, Babbie (2010) advocated reliability, where the quality of the data collected is such that the same data would be collected in repeated observations of the same phenomena. Measurement of these
data is conventionally through a Likert-type scale, which gives a choice of three or more responses (e.g. a five-point scales ranging from strongly agree to strongly disagree).

For quantitative research, data can be collected from official sources such as statistics or reports, or from published data such as media reports quoting sources. Primary research data can also be gathered from observations of a sample, such as the number of people attending a venue, or from a data gathering instrument, such as a survey (Ary, Jacobs, Razavieh, & Sorensen, 2007).

For quantitative research, the statistical approach signifies the extent to which the data is likely to occur by chance (Muijs 2011). In statistics, this is the significance level and related to the critical $p$-value, which is the probability of encountering data at least as extreme as those that were observed, given an appropriately generated sample. A significance test of 5 per cent is conventional in social research, thus the $p$-value of 0.05 or lower is acceptable for generalisability; however, a smaller $p$-value may not indicate a stronger relationship, merely a greater sample size. Muijs (2011) noted that as well as this issue there is a problem with an arbitrary cut-off point. Two measures proposed to address the issues of $p$-values are confidence levels and effect size. The confidence interval is a range of values between which the value can fluctuate using a 95% cent probability; that is, the confidence interval includes the true value 95 times out of 100. Confidence intervals therefore reflect the results at the level of data measurement, which $p$-levels do not. Effect size, according to Muijs (2011), measures the strength of the relationship between two variables in a statistical population, so that results can be compared with other studies. However, effect size cannot indicate whether the sample results could be duplicated in the total population.

3.2.3 Qualitative approaches and qualitative analysis

Qualitative approaches to research are used extensively in the social sciences (Neumann, 2005). Punch (2005) explained that the qualitative approach has no commonality of procedures such as are employed in quantitative research, and that it includes a multiplicity of methodologies and research practices. Unlike
the generally positivistic paradigm of quantitative research, qualitative study is
often pluralistic and multi-dimensional, and may be positioned in positivism, post-
positivism, critical theory, or constructivism (Creswell, 2011). The aim of qualitative
researchers is to achieve an in-depth understanding of human behaviour, and trace
the factors that are inherent in such behaviour (Creswell, 2011). Punch (2005)
states that qualitative research is a political process, as it is framed and presented in
a series of constructs: human discourses that are to an extent bounded by social
arrangements of power, funding, and negotiation. Qualitative research is also often
naturalistic, as it studies people in their natural settings. A qualitative study tends to
delay analysis of the data and conceptualising until later in the research process, so
it is unlike quantitative data collection where there is a pre-existing conceptual
design and framework and the data collection is highly structured (Gray, 2009).

Another characteristic that typifies this approach is intense or prolonged
contact in the field, where the researcher attempts to gain an overview, or a holistic
view, of the subject matter, seeking the structure and the explicit and implied
factors that relate to it (Miles & Huberman, 1999). Furthermore, the researcher’s
role is to capture the perceptions of the study participants as data, focussing on
their explanations, views and contributions to the study, with no preconceptions
regarding that data. There may be some further referral on a subject matter with a
participant, but that should be for reference purposes later in the study. The
purpose of the data collection is to explain why people hold particular views or the
value of their experience to the topic, so that many interpretations are possible,
although commonality of responses does allow consistency to emerge from the
analysis. For this reason, there is little standardising of the data collection
instrument. Data analysis generally utilises words, from which key phrases, trends,
or patterns can emerge.

Earlier qualitative design, according to Creswell (1998), could be categorised
as biography, ethnography, grounded theory, case study, and phenomenology. To
this list of possible methodologies, Denzin and Lincoln (2011) add historical method,
action and applied research, and clinical research. Qualitative design begins with
asking a range of questions regarding the manner by which the design will connect
to the theory through the empirical data, who or what will be studied, and what methods or instruments will be used.

There are many methodologies that can be described as qualitative. Several well-known and often used approaches are outlined below, including grounded theory, phenomenology, and case study.

**Grounded theory**

Grounded theory was proposed by Glaser and Strauss (1967) as the discovery of hypotheses from empirical data. Verification, central to existing research design at the time, was moved from prior to theoretical discovery to post theory; that is grounded theory is developed prior to moving on to the steps of verification. Glaser and Strauss adopted a process of theory, so that conceptual categories and their conceptual properties are adopted first, and these may lead to hypotheses. Categories and their properties are concepts that are separate; however there is a systematic relationship between the two concepts, although categories are a higher form of concept than properties, although both emanate from the data. Concepts should be analytical, that is, generated as characteristics of concrete elements, not the actual elements themselves. Concepts should also be responsive, and understandable within the individual’s experience. The relationships between concepts form the basis for hypotheses. As categories and properties are developed, relationships emerge as an integrated framework, and this forms the core of the grounded theory.

**Phenomenology**

The evolution of phenomenology in the 20th century is explained by Patton (2002) referring to the work of Husserl (1962) as: “how people describe things and experience them through their senses. His most basic philosophical assumption was that we can only know what we experience by attending to perceptions and meanings” (Patton, 2002, p. 105). The researcher therefore explores the experiences of people; their interpretations, views and thoughts on the topic under discussion, drawing out meanings and trends that the study participants hold in common, and noting where they diverge. Merriam (2009) described this as the
researcher discovering and depicting the basic structure of experience by using the phenomenological interview. However, the researcher must first explore his or her own interpretation of the phenomenon, identifying personal prejudices, assumptions and views. These are then acknowledged, bracketed and set aside, so that the researcher can clearly hear the voice of the study participants. Further, a process of phenomenological reduction is undertaken by which the phenomenon under scrutiny is isolated from its environment to allow the continual return to its core elements. Horizontalisation is the manner in which all the data are laid out for examination and all data are regarded as having the same weight so that they can be arranged in themes or as clusters (Moustakas 1994). Moustakas claimed that in this explicating process, every perception has an equal value, qualities are recognised and described, non-repetitive elements are linked thematically and a full description is derived.

**Case study**

A case study approach, according to Flyvbjerg (2006) is an in-depth examination of a single example. Feagin et al. (1991, p. 11) stated: “A good case study provides a full sense of actors’ motives that eventuate in specific decisions and events” (for a discussion of motivation and intention, see Chapter 2).

Stake (1995) classifies case study research as:

- Intrinsic: to have an intrinsic interest in understanding a case;
- Instrumental: using cases to gain a better understanding of an issue or theory; and
- Collective: as a larger version of the instrumental study that compares and contrasts across multiple cases.

The efficacy of the case study method, however, has been questioned. This includes the argument that theoretical knowledge is of greater value than empirical knowledge; that a single example study cannot be generalised; that the case study can generate a hypothesis, but other approaches are more suitable for hypothesis testing and theory building. Flyvbjerg (2006) addressed points critical of case study’s effectiveness, arguing that “a scientific discipline without a large number of thoroughly executed case studies is a discipline without systematic production of
exemplars, and a discipline without exemplars is an ineffective one” (Flyvbjerg 2006, p. 219).

**Other qualitative designs**

The remaining qualitative designs suggested by Denzin and Lincoln (2011) are *action* and *applied* research, *historical* method, and *clinical* research. Action or applied research differs from other exploratory methods as the researcher is involved in the process, and becomes a change agent. Historical method is part of an investigation whereby the phenomenon is taken from the existing set of circumstances under study into the past to identify stronger themes. Interviewing in clinical research differs from other interviews in that the participant’s perspective is superseded by the interviewer’s knowledge of an appropriate intervention, as occurs in a medical setting.

Within qualitative research there is a range of research strategies for employing theoretical frameworks, collecting and analysing data, forming findings, writing the discussion and narrative, and applying standards to establish rigour.

**Validity in qualitative research**

*Validation* of the qualitative design process occurs in two areas (Flick, 2009). The first relates to the phenomenological discussion whereby the researcher is successful in bracketing prior knowledge, assumptions and biases regarding the subject under study, and setting them aside whilst data collection takes place (Merriam, 2009). The second area of validation, according to Flick (2009), is the transparency of phenomena and the inferences drawn from the data in the discussion. Procedural validation can be achieved by truthful recording, complete reporting and seeking feedback during the procedure of qualitative research (Wolcott, 1990).

The transactional approach to validity of a qualitative approach features techniques such as checking by members, as defined by Guba and Lincoln (1989), with the transformative challenge of validity being coming to ideal conclusions (Wolcott, 1990).
Thus validation occurs when there is sensitivity to the relationships between the phenomenon and the stakeholders in the study; that is, by building integrity into the process and the product of the research. In this study, the researcher’s prior knowledge, assumptions and biases were bracketed from the data collection with care taken to achieve honest and truthful reports with feedback from supervisors during implementation of the study.

**Reliability in qualitative research**

Research that provides observations consistent with the finding of similar studies or with the results of a reevaluation test is considered reliable if the same method has been used (Corbin & Strauss 2008; Guba & Lincoln, 1994; Creswell, 2009). Patton (2002) considered three criteria in determining reliability of data in qualitative research: standardising techniques used in data gathering to confirm findings; the clarity of the researcher’s qualification; and the background and type of assumptions inherent in the study.

The definition of validity and reliability developed by quantitative study however changes in the qualitative domain where the traditional concepts here “are conceptualised as trustworthiness, rigour and quality in qualitative paradigm” (Golafshani, 2003, p. 604).

**Generalisability in qualitative research**

The majority of qualitative researchers generalise from a conceptual process: an analytic approach or a case-to-case transfer. Due to the nature of qualitative research, if has been argued that the terms validity, reliability and generalisability cannot be applied to this type of research; instead the terms **credibility, transferability, and trustworthiness** are used (Golafshani, 2003, p. 600). Guba (1990) suggested four types of **trustworthiness** criteria for constructivism: **credibility** (paralleling internal validity), **transferability** (paralleling external validity), **dependability** (in preference to reliability) and **confirmability** (in preference to objectivity). Credibility is when the researcher tries to provide a true presentation of the phenomenon. Transferability is when the reader is able to apply findings to similar and familiar settings. Dependability, although difficult to achieve, means
trying to enable other investigators to replicate the same inquiry. Finally, confirmability refers to the researcher providing justifiable evidence, so that it is clear that the findings have emerged from the data and is not tainted by the researcher’s bias or views. In this study the survey collected data to show generalisability and the interview looked for creditability, trustworthiness and transferability or external validity of data.

In summary, qualitative research is a naturalistic procedure used to achieve an in-depth understanding of human behaviour, and trace the factors that are inherent in such behaviour (Creswell, 2011). The researcher’s aim is to discover participants’ perceptions and experiences by using phenomenological interviews, and thereby being in a position to depict the basic structure of an experience (Merriam, 2009). In this process, every perception has an equal value, qualities are recognised and described thematically and a full description is derived to address the research questions (Flick, 2009).

3.2.4 Mixed methods

To overcome criticisms inherent in both quantitative and qualitative designs, Teddlie and Tashakkori (2009) and Creswell (2009) advocated a mixed methods approach, which adopts aspects of both quantitative and qualitative approaches to gain a better understanding of the research problem. Collecting both closed and open quantitative and qualitative data allows for the validation of both forms, as well as the integration of the two data sets through their merger or through sequential collection. The relationships inherent in a mixed method design are described by Mertens (2010) under pragmatic and transformative paradigms depicted in Table 3.2.
Table 3.2

*Mixed method design* (Source: Mertens, 2010, p. 299)

<table>
<thead>
<tr>
<th>Temporal relationship</th>
<th>Philosophical paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pragmatic characteristics</td>
</tr>
<tr>
<td>Parallel</td>
<td>Both quantitative and qualitative data are collected to answer the research questions. Two types of data collected simultaneously or with a minimum time lag.</td>
</tr>
<tr>
<td>Sequential</td>
<td>One type of data provides the basis for collection of another type of data. Answers one type of question by collecting and analysing two types of data. Inferences are based on the analysis of two types of data.</td>
</tr>
</tbody>
</table>

The pragmatic characteristics of the *parallel* mixed method design is described by Mertens (2010) as the collection of qualitative and quantitative data for the purpose of answering a single study’s research questions, with findings based on both. Creswell (2009) refers to this as an embedded design. Its transformative characteristic, according to Sweetman, Badiee, & Creswell et al. (2010, p. 441) “seeks change through incorporating intent to advocate for an improvement in human interests and society through addressing issues of power and social relationships”. Transformative research design therefore aims to comprehensively address social issues in greater detail, thus Denzin and Lincoln (2011) call for critical analysis to counter neutrality.

The pragmatic characteristics of *sequential* design are generally the reason why this is the mixed methods design of choice, as the data from a closed quantitative study are deepened or informed by a subsequent qualitative data
collection. This design brings insight into the themes that emerge from the data, or is used to explain anomalies among the quantitative inferences. Mertens (2010) further explained that the reverse can also be a valid approach: where an open inquiry is used to inform a quantitative design instrument to appropriately focus on issues concerning the research problem. The transformative characteristics of sequential design are to promote change at any level from the personal to the political. This is the mixed method design that is appropriate for this research due to its multifaceted nature.

Once a mixed methods sequential study has been chosen, there are a range of methodological issues that need to be addressed. These include decisions about resources: whether the quantitative or the qualitative instrument has the greater weight – that is, does one approach predominate, or is one approach informed by the other (Ivankova, Creswell, & Stick, 2007). Whilst each design approach has its inherent steps, the combined approach of mixed method design, particularly using a transformative paradigm, requires clarification of the design procedure. Ivankova et al. advised that in order to produce robust analysis, and to take advantage of the strengths of each approach, the sequences of data collection need to be decided upon in advance, as does when the two flows of data, inferences, themes, or trends are compared.

Falk and Guenther (2007) argued that in a mixed method approach, generalisability is possible when the same finding emerges from the mixing of quantitative and qualitative methods, leading to theory building. As this work benefited from both qualitative and quantitative methods of data gathering, the reliability of the survey was confirmed by the interview and the findings from the interviews supported the responses to each question of the survey. Together the data from the survey and the interviews complemented and confirmed the analysis of each, hence enhancing the reliability of study.

3.3 Rationale for the research design for this study

The methodology for a research project is dependent on the underlying paradigm and for this study, this paradigm is constructivist. Deciding on a
methodology depends on issues and key factors that need to be accumulated and managed in designing the research method (Maxwell, 2005), and, in particular, the research question being addressed.

### 3.3.1 The research questions

The overarching research question driving this multifaceted research is:

**RQ** What factors influence students’ decisions to study mathematics at university?

These factors may involve individual preferences, as well as students’ social, educational, economic, and cultural backgrounds (Forgasz, 1998). So different research instruments are required to examine the nature of the different variables (Arksey & Knight, 1999).

The subsidiary research questions for this study are:

**SQ1** What *pathways* into the study of courses involving mathematics are reported by undergraduate students?

**SQ2** What do undergraduate students of mathematics perceive to be the *value* of studying mathematics at university?

**SQ3** What do undergraduate students of mathematics perceive to be the influence of their *school experience* on their decisions to study mathematics at university?

**SQ4** What do undergraduate students of mathematics perceive to be the influence of their *family backgrounds* on their decisions to study mathematics at university?

### 3.3.2 Rationale for using a mixed methods approach

Both quantitative and qualitative approaches are incorporated in this research. According to Maxwell (2005), designing a mixed methods approach reduces problems associated with the use of one single method. A mixed methods approach is seen as necessary to identify students’ perceptions of the factors influencing their choice of course, while each factor also needs to be examined in detail. While each method has strengths and weaknesses, a mixed method
approach enhances their strengths and minimises their weaknesses, thereby providing deeper understanding of the issues and credibility of the results (Bryman, 2004). The rationale for the selection of each method will be discussed next.

Identifying the factors influencing students’ choices is not fundamentally numeric in nature and therefore suggests that the collection of qualitative data can provide insights into students’ beliefs, attitudes and reasoning (Denzin & Lincoln, 1998, 2011). Nevertheless, the qualitative collection of data can also be analysed quantitatively to answer research questions (Muijs, 2011). Thus this study incorporates both qualitative and quantitative data particularly during data analysis.

Qualitative data in this study was captured through the survey followed by individual interviews, where issues could be explored in-depth (Patton, 2002). The surveys were based on both multiple choice and open response questions yielding unstructured qualitative data (Bryman, 2004). Qualitative data from the interviews was analysed using a case study method to gain insight into responses and to enhance knowledge. The Eccles and Wigfield’s *Expectancy Value Theory of Motivation* (see Chapter 6) framework provided a structure for classification of responses. As Shortell (1999) noted, the increasing use of interviews in qualitative research is consistent with the progress of social science and the need for more in-depth knowledge of naturalistic contexts and the complexity of employing social change.

Surveys can be used to collect both qualitative and quantitative data (Punch, 2005). The numeric results from qualitative data from the survey were also analysed using descriptive statistics and chi-square tests, producing quantitative results and statistical information (see Chapter 5). The qualitative data were quantified to isolate patterns or trends in the data.

*While this research is constructivist, its ontology is relativist, or in other words, the belief that reality is socially constructed and therefore has multiple interpretations* (Guba, 1990). From an epistemological standpoint, the factors influencing students’ choices are derived from the multiple realities presented by the study’s participants. The elements of epistemology are categorised into: a) the empiricism or the observations (surveys and interviews); b) analysis of the researcher’s ideals (the researcher’s own understanding or innate knowledge
without observation; and c) rationalism which is the balance between empiricism and idealism (Teddlie & Tashakkori, 2009).

3.3.3 Survey rationale

One research method selected for data collection in this study was a survey administered to first year university students enrolled in at least one mathematics subject. The survey questions were generated from the theoretical and empirical literature and tailored to fit the purpose of this research, in order to achieve findings that will contribute to the body of knowledge in this field. Questions asked in the survey examined students’ psychological, educational, cultural and socio-economic backgrounds, in addition to their attitudes to and their involvement with mathematics now, in the past, and in the future.

The forms of quantifiable data in surveys are attitude scales and personality inventories: the former relate to beliefs, experiences, attitudes, perceptions and other constructs relevant to the research questions; the latter refer to checklists and selections relating to personality attributes of the study participants (Teddlie & Tashakkori, 2009). The questions in a survey are normally highly structured so that the data can be analysed through statistical measures. However, Galasiński and Kozłowska (2010) argued that closed questions alone are inadequate to form valid conclusions, “particularly the notion that such conclusions offer insight into informants’ experiences” (p. 271).

Validity relates to measuring the decision-making processes of participants with questions from which deductions can be made that accurately reflect the purpose of a study – that is, content validity (Muijs, 2011). Content validity was determined in this study through a literature search and from a pilot study that asked participants whether they considered the survey questions valid.

3.3.4 Interview rationale

Further data collection for this study was completed by interviewing a selection of willing students who were selected according to their responses to the survey. The rationale for choosing individual interviews is based on the
constructivist paradigm that individuals construct their own versions of reality (Guba 1990). Choosing individual interviewees to follow up the written survey provided the opportunity for participants to elaborate on or add their own perceptions, thus providing more information about factors influencing their decisions (Shortell, 1999). In personal, face-to-face interviews there is a greater chance of building empathy between the parties, and that rigid question structures may be more readily extended to gather rich data with which to inform the study (Cohen, 2007).

To ensure procedural validity, the study was informed by Patton’s (2002) recommendations for conducting interviews:

- the researcher should refrain from speaking as much as possible and concentrate on listening;
- the interviewer should produce notes as soon as possible, writing clearly and expressing the interviewee’s views so that a reader of the notes can make inferences from the data and the report should be as complete and candid as possible; and
- the researcher should seek feedback from colleagues in the field by presentations of findings.

To enhance the validity and reliability of interview data in this study, every effort was made to ensure the social appropriateness of statements, and correct recording of statements and points of view. As Flick (2009) explained, the interviewer may not be conscious of body language or showing an interest that may influence the interviewee’s responses, so the interview should be analysed for systematic problems in the text that may emerge from the interview situation. Flick recommended discussing this point with the interviewee and asking the interviewee to later validate the transcript.

In this study the interview data was also coded using a theoretical framework judged as appropriate for answering the research questions. This is discussed in Chapter 4.
3.3.5 Case study rationale

The results of the coding for individual interviews was used to construct case studies of participants who met particular criteria judged as relevant for this study (see Chapter 6). According to Simons (2009), a case study should be selected when interview data provides insights into singular and unique events. In this case, the individual participants were selected according to defined criteria. Accordingly, a detailed contextual analysis was undertaken of a limited number of students in relationship to particular portrayed events (Yin, 2009), that is, experiences, pathways, and decision-making related to choosing to study mathematics at university.

Case studies are used across a variety of research areas, mostly in sociological studies. Researchers experienced in this methodology, such as Yin (2009), Stake (1995) and Feagin et al. (1991), have developed rigorous procedures that can be tested in a scientific manner. It was expected that, in addition to surveys and interviews, the construction of case studies will add strength to the application of ideas addressing the research questions.

The case study offers a significant capacity in this study for understanding the complexity of students’ situations with respect to choosing to study mathematics. When understandings are generated through an in-depth case study from a holistic perspective, the results can be viewed as exceptional and universal (Stake, 1995; Yin, 2009). The case study is most useful when the boundaries between the phenomenon of students’ decisions and their influencing factors, which Yin (2009) refers to as “context”, are not clearly evident and when multiple sources of evidence are used (Yin, 2009). There are multiple sources of evidence: archives, artefacts, observation, interviews, and surveys (Eisenhardt, 1989). The last two sources – interviews and surveys – are used in this study.

As mentioned earlier, the term “case study” can refer to either single or multiple-case studies (Yin, 2009). The case can also be holistic or have embedded sub-cases within an overall holistic case (Yin, 2009). For example, choosing mathematics at university is a holistic case where the impact of parents’ educational background is a sub-case that can produce even more data to empower
the research. The present work explores multiple cases to strengthen the findings of
the study through repetition, as outlined by Huberman and Miles (2002). Repetition
also produces significant improvement in building theory (Stake, 1995).

In summary, this chapter has examined the study’s research design and
research paradigms, and discussed quantitative and qualitative methods of data
collection and analysis, and their blend in this mixed methods approach. This was
followed by the rationale for choosing survey and interview data collection methods
for this study, and case studies.

The next chapter will explore the research processes in detail using
quantitative (survey) and qualitative (interview) approaches, together with the data
analysis instruments.
CHAPTER 4  RESEARCH PROCESS

The purpose of this chapter is to explain the steps taken to collect and analyse data from the survey and interviews based on information provided in Chapter 3 on the methodological approaches suitable for answering the research questions. Investigating the reasons behind students’ choice of mathematics at university included both qualitative and quantitative data analysis methods.

Firstly, an online survey was designed to identify the reasons behind students’ choice of mathematics at university, collecting data from a large group in order to measure the extent and relationships between variables. Individual interviews with a selection of survey participants were planned for the second part of the research, in order to collect rich and in-depth data, to confirm the information collected through the surveys, and to produce evidence for constructing a series of case studies to gain further insight into the phenomena.

The discussion of the research procedure in this chapter describes the steps taken to collect data including: survey participants, sites and instruments, pilot study and data analysis of survey results. For the second stage of the research, ways of getting access to survey participants for selecting interviewees, deciding interview sites, setting the interview questions, and analysing the qualitative data through case studies, are discussed here. Ethical considerations and a summary conclude the chapter.

4.1 The survey

Surveys have several advantages, such as extracting data from a large population at low cost and providing greater accuracy in terms of measuring gathered data (Sincero, 2012). Kraemer, King, Dunkle, and Lane (1989) claimed that survey research is widely improved when used in combination with other methods in research, such as the interview. Surveys enable the collection of qualitative data that can be also quantified (e.g. number of students in each course) or interpreted by qualitative methods where more explanations are needed. The online survey in this study was also designed to identify potential interviewees for the second part
of the research, in order to provide richer information and more understanding of issues that had been discussed in the surveys. An online survey thus was selected as the first step for this research.

4.1.1 Survey population

The target population of the survey were students studying at least one firstyear mathematics subject as part of a range of university courses. First semester undergraduate students of science and engineering are usually offered a mathematics subject at most Australian universities. To avoid omitting elective mathematics students enrolled in non-mathematics related courses, the survey was intended to be sent to all students studying a first-year mathematics subject in Semester One of 2011 at three Australian universities, including those students with little or no interest in mathematics who were required to complete compulsory mathematics subjects as part of their course.

As discussed below, problems related to obtaining ethics approval and difficulties in communicating with appropriate people at two of the three universities initially selected, meant that students from only one university were offered the opportunity to participate in the survey in Semester One. Additional students from this university, together with those from another five universities participated in the survey in Semester Two.

4.1.2 Survey sites

The influence of cultural or ethnic background as explained in Chapter 1 was one of the initial interests of this research. The strong relationships found in the literature between students’ decisions regarding their choice of mathematics and their background characteristics, plus their interest supposedly initiated by cultural factors positioned this study as cultural research (c.f. Ainley, 2004; Bishop, 1994; Fullarton, 2002; Marks et al., 2001; Forgasz 1998; James, 2000; Lyon, 2004; McPhan et al., 2008).

After reviewing research conducted by the Department of Education Employment and Workplace Relations (DEEWR, 2009) into international students
enrolled at Australian universities in different states, it appeared that students of the same nationality or region tended to select and congregate in particular states, with one nationality tending to live in a particular city. This trend is illustrated in Table 4.1.

Table 4.1
International students’ enrolment by state (Source: DEEWR, 2009)

<table>
<thead>
<tr>
<th>State</th>
<th>The Americas</th>
<th>South &amp; East Europe</th>
<th>North-west Europe</th>
<th>Oceania</th>
<th>Southern &amp; Central Asia-India</th>
<th>South-east Asia</th>
<th>North-east Asia &amp; China</th>
<th>Middle-east &amp; North Africa</th>
<th>Sub-Saharan Africa</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>20 720</td>
<td>8 699</td>
<td>8 546</td>
<td>361</td>
<td>53 721</td>
<td>41 613</td>
<td>92 158</td>
<td>10 167</td>
<td>2 249</td>
</tr>
<tr>
<td>VIC</td>
<td>7 175</td>
<td>1 710</td>
<td>4 093</td>
<td>168</td>
<td>72 536</td>
<td>34 095</td>
<td>60 702</td>
<td>6 494</td>
<td>4 226</td>
</tr>
<tr>
<td>QLD</td>
<td>15 468</td>
<td>2 534</td>
<td>7 775</td>
<td>808</td>
<td>24 094</td>
<td>10 253</td>
<td>35 516</td>
<td>5 431</td>
<td>1 295</td>
</tr>
<tr>
<td>WA</td>
<td>4 546</td>
<td>1 101</td>
<td>3 363</td>
<td>19</td>
<td>9 507</td>
<td>11 998</td>
<td>12 281</td>
<td>2 311</td>
<td>4 578</td>
</tr>
<tr>
<td>SA</td>
<td>1 018</td>
<td>290</td>
<td>1 080</td>
<td>25</td>
<td>8 150</td>
<td>5 431</td>
<td>16 104</td>
<td>1 151</td>
<td>466</td>
</tr>
<tr>
<td>ACT</td>
<td>468</td>
<td>122</td>
<td>372</td>
<td>47</td>
<td>1 230</td>
<td>2 032</td>
<td>4 775</td>
<td>487</td>
<td>167</td>
</tr>
<tr>
<td>TAS</td>
<td>221</td>
<td>46</td>
<td>198</td>
<td>14</td>
<td>272</td>
<td>1 321</td>
<td>2 459</td>
<td>390</td>
<td>64</td>
</tr>
<tr>
<td>NT</td>
<td>45</td>
<td>12</td>
<td>62</td>
<td>7</td>
<td>264</td>
<td>406</td>
<td>179</td>
<td>26</td>
<td>25</td>
</tr>
</tbody>
</table>

As can be seen in Table 4.1, the number of international students enrolled in New South Wales is higher than other states, while students from Sub-Saharan Africa, and southern and central Asia, are generally enrolled in Victoria. Students from Oceania are enrolled at universities in Queensland. In comparison, Queensland has larger enrolments of students from the Americas and all European countries than Victoria. As a result, the three states of New South Wales, Victoria, and Queensland host the largest number of international students, with the exception of Western Australia, where the number of South East Asian students is 1,745 higher than Queensland. The states of Queensland, New South Wales and Victoria were chosen for this study as the frequency of each culture in each state meant that missing one of these three states would result in missing a cultural group.
Participants from any given university possibly do not represent the high diversity of international students because of their geographical location, enrolment criteria, and courses that might be suited to just some particular group of students. Furthermore, they may not represent undergraduates from varying ethnic groups who have selected mathematics at large universities located in different capital cities, where large numbers of students are enrolled in a variety of courses and come from different backgrounds. This study includes a comparison of factors influencing different groups of students in their choice of university course. The literature (e.g. Bishop, 1994; D’Ambrosio, 2003) also identifies cultural attitudes in this regard. It was assumed that selecting samples with greater multicultural complexity will provide richer data for this research.

After selecting states with a greater variety of international students, the enrolments by international students in natural and physical sciences in all universities in the three states were examined. This comparison helped identify those universities with higher numbers of international enrolments.

In order to protect their privacy the universities involved in the survey were given pseudonyms. Historical university documents (e.g. Marginson & Considine, 2001) were reviewed to select relevant pseudonyms. For example, Redbrick universities (RB) were established to be innovative pedagogically in science and engineering. Sandstone universities (SS) tend to be the oldest in their state. Universities based more on technology are named after their specialities (TEC).

Following the design of the survey, the next step was finding ways of gaining access to survey participants and communicating with different universities in different states. In order to obtain useful data, the selection of appropriate research sites or universities was as crucial as developing the survey. After research into the availability of different universities for conducting the survey, three major universities in the three Eastern states of Australia, SS1, RB2, and SS3, were contacted by the researcher. Two of the three universities, SS1 and SS3, accepted and agreed to publish the online survey on their websites, but RB2 decided not to participate because of the belief that their students had been “over surveyed” during that academic year. Based on the two remaining universities’ written
agreements, the survey was emailed to designated departments, together with an introductory letter requesting faculties to post the survey on student websites.

There were, however, problems during Semester One in 2011 due to RB2 not participating in the survey and SS1 experienced technical problems posting the survey on the student website. As a result, SS1 agreed to publish the survey in Semester Two, but RB2 with the largest number of mathematics students still refused to be involved in the survey. The researcher therefore tried to contact more universities with similar criteria hoping to find a substitute for RB2 in order to contact a greater number of participants for the survey. Four universities in two states accepted invitations to participate in the survey and to post the survey on their websites at the beginning of Semester Two 2011.

Table 4.2 gives details of international student enrolments and numbers of students studying natural and physical sciences for the six universities that finally took part in the survey. Codes for these universities are: Sandstone 1 (SS1); Sandstone 2 (SS2); Sandstone 3 (SS3); Multi Campus (MCS); Technology 1 (TEC1); and Technology 2 (TEC2). Multi Campus (MCS) was also selected to provide representation by students from a regional, multi-campus university.

<table>
<thead>
<tr>
<th>State</th>
<th>University</th>
<th>Domestic students</th>
<th>International students</th>
<th>Natural &amp; physical science students</th>
</tr>
</thead>
<tbody>
<tr>
<td>State 1</td>
<td>SS1</td>
<td>38 463</td>
<td>11 969</td>
<td>5 749</td>
</tr>
<tr>
<td>State 2</td>
<td>MCS</td>
<td>23 070</td>
<td>7 501</td>
<td>2 406</td>
</tr>
<tr>
<td></td>
<td>TEC1</td>
<td>24 523</td>
<td>24 710</td>
<td>2 623</td>
</tr>
<tr>
<td></td>
<td>SS2</td>
<td>33 443</td>
<td>12 005</td>
<td>7 702</td>
</tr>
<tr>
<td>State 3</td>
<td>TEC2</td>
<td>34 167</td>
<td>6 403</td>
<td>2 196</td>
</tr>
<tr>
<td></td>
<td>SS3</td>
<td>31 757</td>
<td>8 826</td>
<td>5 461</td>
</tr>
</tbody>
</table>

The selection of these six universities increased the sample size, giving findings greater applicability and relevance. These universities were selected as they exhibited similar demographics, which maximised homogeneity in the sample populations. Homogeneous sampling facilitates focusing and reduces variation. It
also helps the researcher simplify analysis (Patton, 2002) and in the case of this study, assisted grouping samples for the interviews.

It was impossible to ascertain the total number of first-year students enrolled in mathematics units as universities maintained that this data is not available. However, the information in Table 4.2 that there were a total of just over 26,000 students enrolled in natural and physical sciences at these six universities appears to confirm the estimates given by these universities that the total number of first-year students enrolled in mathematics units was approximately 8000 — that is, a little under a third of the total. However, this total needs to be treated as an upper estimate as the universities were not always able to reach all first-year students enrolled in mathematics units.

The online survey was administrated during Semester One at the beginning March 2011 and during Semester Two in early September 2011. The survey attracted 545 participants who consented to be part of the survey, but only 391 actually continued to answer any questions (a response rate of approximately 5%). The 154 participants whose responses didn’t contribute to the survey effectively or who did not give any responses to the survey questions were excluded. Issues relating to generalisability of findings in relation to the sample are discussed in Chapter 8 in relation to limitations of the study. Issues include the possible impact of the open nature of the first question in the survey.

4.1.3 The survey questions

The survey (see Appendix 1) was designed to collect data relating to the factors influencing students’ choice of mathematics at university and ultimately to answer the study’s multifaceted research questions.

In designing a survey, issues such as the type of data (e.g. numerical, verbal or textual) need to be considered (Johnson, Sandford, & Tyndall, 2008) and methods of collecting information (e.g. census, sampling, or administration) need to be decided (Judson & Bauder, 2000). Data gathered for this study was in the form of responses to an online survey administered to undergraduate mathematics students. An online survey was selected for dissemination, completion, and
electronic return, in order to access a large number of potential participants in a limited amount of time, with the advantage of minimising cost (Evans & Mathur, 2005). A plain language statement describing the purpose of the survey, students’ rights, and the survey procedure accompanied the survey questions.

Substantial effort was invested in designing the survey to attract a variety of responses to all issues identified in the literature as relevant to the study. In order to find answers for the research questions as listed in Chapter 3, the survey was designed with 42 questions divided into a number of major groups including: cultural, educational and financial background; questions concerning students’ attitudes, beliefs and values toward mathematics; and students’ experiences and plans in studying the subject in the present, past and future.

Some of the survey questions asked students to respond using a Likert-type scale indicating their degree of agreement by checking the appropriate response from strongly disagree, disagree, agree and strongly agree, to a statement such as “I have always liked mathematics” (Question 19). Other questions were multiple choice, or with the possibility of a yes or no answer – for example “Do you think the grades you received for your mathematics subjects accurately reflect your achievement in mathematics? (Question 24). Multiple-choice questions were asked using different pre-set answers – for example “If you did mathematics subjects at Year 12, which of the following best describes your result?” (Question 23).

Open responses questions can sometimes best explore an issue in-depth or explain a phenomenon – for example “Please comment on the factors you think have influenced your choice of mathematics subjects or units at university” (Question 1). These open response questions were included in order to obtain more detailed explanations through the variety of answers.

The last question in the survey asked students if they would agree to participate in an interview and, if they did, to provide their contact details. In this way potential participants for the interviews could be identified.
4.1.4 Piloting the survey

A survey that is well constructed, informed by the literature, and answers research questions should be examined before posting on participants’ web sites. This includes estimating the expected response rates, checking the data quality and the validity and comprehensibility of the survey (Silman & Macfarlane, 2001). The survey was therefore tested on three students enrolled in: first-year science and mathematics education (three mathematics subjects); first-year accounting (one mathematics subject); and first-year engineering (two mathematics subjects). These three students were enrolled in three different states, doing three different majors with different mathematics loads. All three students completed and returned the survey and reported that they did not have any language difficulty nor found any ambiguity in the nature and content of the survey questions.

The purpose of the pilot study was to refine the survey and to identify any confusion or misunderstandings in language used (Forgasz, 1996; Coffey & Muller, 2003). As a result, no changes were made to the formatting or wording of any of the survey items after the pilot study.

4.1.5 Quantitative data analysis

This study, on one hand, is classified as qualitative because it primarily aims to illustrate and describe factors influencing the choice of mathematics at university in-depth. On the other hand, the use of statistical tools in measuring and analysing data gives a quantitative character to the work (Muijs, 2011) as it aims to produce numerical findings as well, such as frequencies, percentages, and graphs, which assisted in the analysis of the qualitative survey results.

Several approaches were used to analyse the qualitative data produced by the survey – for example, descriptive statistics were used for some items (e.g. categorical data collected about students’ courses or place of birth) that were converted into percentages so that the result could be described in a meaningful and relevant way. However, care should be taken when interpreting these percentages because we cannot assume that they refer to attributes of a wider population, but instead describe attributes of the sample.
Where applicable, data collected in the online survey using Survey Monkey was automatically collated to provide numeric results, including percentages, tables, and graphs. Where appropriate, chi-square tests were used to assess the statistical significance of different patterns of responses by different groups of respondents. A chi-square test is generally used to compare observed data with data that is expected to be collected in relation to a specific hypothesis. This is used to determine the probability of any difference between the expected and the observed result occurring by chance (Carter & Carter 1999). Pearson’s chi-square test of independence identifies the degree of association between variables and analyses the dependency of all attributes (factors) on the outcome (Maben, 2005).

As explained in Chapter 3, using qualitative or quantitative approaches to analyse data depends on the nature of the research question. The two approaches are often taken together, as is the case with this research. A combination of responses to quantifiable closed questions and qualitative elaborations (through open response explanations) allowed this study to better interpret and explain the survey results.

The Expectancy Value Theory of Motivation was also used as an analytic framework for both the open response survey questions and the interview responses, with the analysis of the interview data described in §4.2 below. For example, where exact numbers and percentages of students who said their family financial situation affected their choice of university course had been determined from Question 38: “Do you think your family’s financial situation has affected your choice of university course?”, the responses were analysed subjectively and classified as “cost value”. The opposite procedure was taken to quantifying qualitative data – where the coding of textual data enabled tentative statements about the relative strength or salience of various codes.

4.2 The interviews

In this study, individual interviews were carried out to “enhance the reliability of the research” (Palmer, 2008, p. 178) by collecting data in the participants’ own words in a face-to-face purposeful discussion that provided rich
and meaningful information (Arksey & Knight, 1999). Interviews are a suitable method for providing rich data that cannot be gathered by a survey (Charmaz, 2006), allowing students to reflect on their responses to a variety of questions asked in the survey (MacEachren, Cai, McNeese, Sharma & Fuhrmann, 2006). In this research, individual interviews were used as another instrument to examine the contributory factors undergraduate mathematics students identified in making decisions regarding their choice of university courses. In particular, interviews were used to identify individuals’ notions about or information around subject matter (Arksey & Knight, 1999). Yin (2009) views individual interviews as a particular portrayal of events, circumstances and relationships, while Simons (2009) sees interviews as the study of singular and unique events; in the case of this research, selecting a university course.

Interviews convey deeper insights about the ways participants think and this maximises their input into the research data by verifying concepts that emerged in the analysis of the survey data. Students could also be directed to topics from the survey that required more clarity. The interviewer had access to participants’ survey responses during interviews and, as the interviews moved forward, students remembered more about their responses to the survey in response to some clarifying questions. Students could then remember their survey responses and provide more insight into areas that were needed. Arksey and Knight (1999) have warned of the possibility of interviewer bias, however, participants in this study were given enough information about the aims of the research and sufficient time to add as much as they wanted, thus minimising the possibility of any kind of compromise.

Students who participated in interviews presented rich information about the influence of their background when planning their university course of study – for example, their parents’ support, teachers’ strategies, peer advice, and their own interest in or anxiety about mathematics.
4.2.1 Interview participants

Participants in the individual interviews were selected from the survey sample (see §3.3.2). Students who indicated their willingness to take part in the interviews were listed as potential interviewees and their responses were closely analysed with the aim of finding at least one match with the designated selection criteria for recruiting interview participants. This strategy was based on a set of characteristics identified in the literature review and survey results as explained below.

Strategy for selecting potential interview participants

The interview participants were selected to reflect the following sources of variation.

1. Motivation
   a) Some who were clearly intrinsically motivated
   b) Some who were clearly extrinsically motivated

2. SES
   a) Some whose parents’ occupations suggested high SES
   b) Some whose parents’ occupation suggested low SES

3. Orientation towards mathematics learning
   a) Some who were doing mathematics majors and who indicated that they liked mathematics
   b) Some who were doing mathematics as a course requirement and indicated that they didn’t like mathematics

4. Influence of cultural background
   a) Any who mentioned cultural background or family or parents as influential and said interesting things about this
   b) Ethnicity

5. Influence of friends and peer group
   a) Any who mentioned peer-group influence or perceptions of mathematics by their peer group

6. Choice of course
a) Some who were doing the course as their first choice
b) Some who did not get their first choice and wanted to study something other than mathematics

In summary, criteria for being selected to participate in the interviews included: students evidencing internal and external motivation; students from low and high socioeconomic family backgrounds; students who were who doing a mathematics major and liked it and those who were doing it as part of their course and did not like it; students who reported their choice of course was affected by peer influence, ethnicity, family or parental culture; and students who indicated that their current course was and was not their first choice.

During May, August and September 2011, after the completion of the Semester One and Two surveys, the responses were analysed and interviewees were selected from those participants who agreed to being interviewed, using the selection strategy described above.

The number of individual interviews was constrained by both the researcher’s and the students’ availability and the criteria mentioned above, although it is acknowledged that a greater number of interviews permits more validation of the analysis (Bryant & Charmaz, 2007).

Based on the application of the selection strategy above, 35 students were finally selected from the 126 who agreed to be interviewed. These students were contacted by email and telephone during late September and early October 2011. Twenty-eight students subsequently agreed to participate in the interviews. The first group of students were interviewed in the last week of September in State 3; then the second group in mid-October in State 2; and the third group in late October in State 1. Students were allowed to choose a suitable time between 9 am and 5 pm on one of three nominated days. However, one student from SS1 did not attend, thus making the number of interviews 27.

4.2.2 The interview questions

The interview questions were developed at the same time that the survey was designed. A semi-structured interview protocol was adopted for this stage as
the progress of interviews usually depends on the interviewee’s initial answers, the interviewee’s interest in specific topics, and the trend of the interview in general by what has been suggested by previous experiences (Charmaz, 2006).

Interview questions must focus on similar areas to the focus of the survey so that they are relevant and meaningful (Arksey & Knight, 1999; Teddlie & Tashakkori 2009). Questions emerging during the interview process, as Charmaz (2006) has suggested, also provided data linked to participants’ motivations in their choice of university course. However, the relevance of unstructured questions were considered as they were intended to establish a bond between the interviewee and interview topic so that more complex questions could be asked (Campion, Campion, & Hudson, 1994; Stacks, 2002). Interviews began by referring to one of the questions answered in the survey and the answer was developed by creating relevant questions related to an interesting part of the answer. This procedure continued until the topic was saturated and the next question was asked. Data saturation occurs when no further new information can be seen or heard (McKibbon, Eady, & Marks, 1999). The interview questions (see Appendix 2) included the following six parts, linking the interview with the previously completed survey. In addition, the qualitative data collected through the interviews also gave students an opportunity to: prioritise items they had mentioned in previous questions (e.g. Questions 12 & 16); provide reasons for their belief in the value of the decisions that they had made (e.g. Questions 15 & 20); and explain their responses regarding the influence of factors provided in the survey (e.g. Questions 33 & 36).

1. Educational background

Educational background is relevant to this study because of the range of variations that might be expected. These variations range from an overall positive or negative educational experience due to academic success or failure in mathematics, positive or negative self-image, positive or negative relationships with teachers. These skills, beliefs, and attitudes can have an influence on future educational choices (Behm & Lloyd, 2006). Educational background can influence expectations of success in future studies and can also reflect on the type of value
that interviewees have previously derived from mathematics learning, as identified in the literature review (e.g. Eccles & Wigfield 2002). In the survey, Questions 1 to 19, and 41 related to this topic.

2. **Career aspirations**

Participants with particular career aspirations could reveal ways in which career aspiration might feature in their reasons for choosing mathematics. Interview questions investigated interviewees’ *awareness of the role of mathematics in the prospective job market* and whether future employment and career aspirations featured as an influential factor in their decision to study mathematics. Students sometimes expressed attainment or utility values when they are imagining relationships between their mathematical knowledge and their career choice (Elliot & Murayama 2008). In the survey, Questions 1, 12, 14, and 41 relate to this topic.

3. **Cultural background**

Culture and ethnic background influence students’ decisions and aspirations in every level of their studies (Marks et al., 2001). Wigfield, Tonks, and Eccles (2004, p. 169) found that motivation and behavioural choices can be reflected by “cultural differences in success expectations and subjective task value related beliefs which in turn likely results from cultural differences in the wide range of social experiences that shapes human development”. Interview questions were therefore designed to explore the degree to which interviewees attributed their decision to study mathematics as being due to cultural background. In the survey, Questions 1, 16, 18, 28, and 30 relate to this topic.

4. **Peers and friends**

The influences of peers, schools, and society on autonomous decisions become stronger during adolescence, with students becoming more liable to be influenced by peers rather than their parents (Zimmer-Gembeck, Siebenbruner, & Collins, 2001). Young people can positively influence each other and inspire friends to improve in school work, sports, making future plans, and in taking responsibilities
seriously, but the influence decreases gradually as they grow older (Savin-Williams & Berndt, 1990). In the survey, Questions 1, 12, 15, 18, and 41 relate to this topic.

5. **Course admission tests and entry regulations**

Interviewing students who had changed their first choice will help to investigate whether the selected course is a student’s first choice and what was their most preferred option before enrolling in an existing course. This revealed their level of confidence and information in undertaking mathematics at university and also the motivational factors in making a second choice and the relationship between their first and second choice in terms of decision making. In the survey, Questions 4 and 17 relate to this topic.

6. **Affective issues**

It is also helpful to understand how, why and when students discovered their interest in mathematics, which is a major aim of this work. It is also important to know if students from different backgrounds have different attitudes towards choosing a mathematics subject or to what extent students taking different kind of mathematics differ in terms of their attitudes towards mathematics. In the survey, Questions 11, and Questions 15 to 25 relate to this topic.

4.2.3 **Interview sites**

It is recommended that an interview be conducted in a neutral and mutually convenient location for both the interviewer and interviewee, such as a library (Stacks, 2002). Libraries are excellent places for interviews because they are easy to access, quiet, safe, and have places for conversations that require some privacy (Jacob & Furgerson, 2012). To provide a neutral location for interviews, the city council libraries in the three states were selected. The city council libraries of State 2 and State 3 also provided a meeting room for this purpose after a short interview with the researcher, who then signed an online agreement, which required information about the purpose of the interviews, their dates and length. Interviews in State 1 were conducted in one of the SS1 libraries as the city council library’s
meeting room was expensive to rent and required the presence of a third person in
the interview room. Students in all three states were provided with the addresses
of the libraries and allowed to select their own university library if it was more
convenient. All interviewees however attended the designated places.

An interview may take between one and two hours (Munhall, 2010) and may
be repeated when inevitable questions arise and gaps in categories in data analysis
appear (Charmaz, 2002). Interviews for this research were planned for half an hour
due to the number of questions and the importance of attracting and retaining the
participants’ interest in the subject matter (Jacob & Furgerson, 2012).

4.2.4 Qualitative data analysis method

Data obtained by interview were analysed using Eccles and Wigfield’s
Expectancy Value Theory of Motivation (Eccles et al., 1998; Eccles & Wigfield, 1995,
2002; Eccles 2009a, 2009b; Wigfield & Eccles, 2000, 1992; Wigfield et al., 2004) as
described in Chapter 2, and the results of this analysis were used to construct
individual case studies. Figure 4.1 presents the construction of an individual’s choice
behaviour based on the “general model of achievement choices” suggested by
Wigfield et al. (2004).

As can be seen in Figure 4.1, the key components of the Expectancy Value
Theory of Motivation consist of: Expectation of success, which refers to an
individual’s self-evaluation of competency in executing a task; Intrinsic value, which
is motivation in doing action for its own sake; Utility value, which is committing to a
task for its usefulness or external value; Attainment value, which refers to
achievements consistent with personal goals and a sense of identity; and Cost
value, which considers the costs in terms of time, resources, money, and other
negative consequences that a task may involve.
To construct a series of individual case studies, eleven students were selected from those interviewed, each representing one of the groups in the selection strategy described in §4.2.1. For example, interviewees included at least one student who showed signs of enthusiasm (intrinsically motivated) and at least one student who studied courses involving mathematics but who was not interested in the subject (extrinsically motivated). The conceptual framework has also been used in the analysis of the interviews and to facilitate comparison between cases.

Although the analysis of the interview data through Wigfield and Eccles’ Expectancy Value Theory of Motivation primarily served the purpose of organising salient factors reported by students, it was also used when counting frequencies of cases exhibiting particular factors. This process supported statements about what aspects of the framework were most commonly displayed and which aspects were infrequent. It was also used to discuss the possible meaning of these observations.
4.3 Ethical considerations and processes

As a requirement for conducting social science research dealing with human participants, researchers are obliged to make themselves aware of the moral principles governing this type of research and ethical issues associated with projects involving participants and colleagues.

The growing popularity and relevance of qualitative research from the mid-twentieth century has placed emphasis on the importance of formal ethical research guidelines (Burton, Gerard, & Irvin, 2004). In designing any study there are values and principles such as participants’ agreement in involvement in the research, ensuring their physical and psychological safety and security, and that the research should respect participants’ integrity (Frankel & Siang, 1999). Ethical concerns in this research related to the ways the research was performed and also how its findings may be used in the future. In both cases, the researcher is obliged to maximise the possible benefit and minimise harm and risk to participants and users. Benefits could be defined as a contribution to knowledge or empowering individuals by giving them a voice, where harm may include psychological abuse or loss of privacy (Frankel & Siang, 1999).

Guidelines such as protection of anonymity, privacy, and confidentiality, preventing undesirable effects, avoidance of dishonesty and conflict of interest, as well as obtaining informed consent, were considered (Burton et al., 2004). A plain language statement and consent form was provided at the start of both the survey and the interviews.

The individual interviews were conducted by signed agreement, and participants could withdraw at any time. Accordingly, information on the purpose of the survey was sent to participants in all phases of the study. A letter that explained the research goals and objectives was also provided.

The research started after obtaining all relevant approvals (Frankel & Siang, 1999). This project obtained Deakin University Human Research Ethics Committee’s clearance through the Faculty of Arts and Education, Human Ethics Advisory Group (HEAG). Once the ethics application process was completed, data collection could commence.
In order to protect participants’ identities, students in this thesis are referred to by their numbers, in the order they started the research survey, ranging from S1 to S391. For the same reasons, states and universities have also been given pseudonyms as explained in §4.1.2.

In summary, this chapter has described the processes used to collect and analyse data to find the factors that influence students’ choice of university mathematics. This included both qualitative and quantitative methods of data collection and analysis, including a survey and interviews, and the use of data collection and statistical tools such as Survey Monkey, Excel and Chi-square tests. Data were collected from six universities across three states. From the 391 students who completed the survey 126 agreed to participate in interviews. Of these, 28 students were invited for interview, with 27 students attending individual interviews. Qualitative data were analysed using Eccles and Wigfield’s *Expectancy Value Theory of Motivation*. Interview data were then used to construct eleven student case studies. This chapter concluded by discussing the ethical issues and procedures relevant to this study.

Chapter 5 presents the results from the survey, while Chapter 6 presents the results from the interviews.
CHAPTER 5   RESULTS FROM THE SURVEY

This chapter presents the results from the survey distributed to first year university students in six universities from three different Australian states (see Appendix A).

5.1 Survey participants

This section describes the sample population, as well as information obtained from the survey regarding the courses in which participants were enrolled, including the nature of the mathematics subjects they were undertaking – that is, whether they were compulsory or elective and whether they were part of a major or minor course of study.

5.1.1 The sample

The study sample, described in Chapter 4, was first year university students enrolled in at least one mathematics subject. To be considered in this survey, the student must have been enrolled in a mathematics subject in one of six specific Australian universities in 2011; the total survey population was estimated at 8000 students. The study attracted 545 students who consented to take part. However, only 391 actually continued to answer any questions. Those 154 participants who did not respond to any of the questions in the survey were excluded from the dataset.

It was not possible to get access to the exact number in the survey population as students enrolling in only one mathematics subject is not recorded as an identified group at universities. Therefore, calculating the response rate was not possible owing to the uncertainty in the number of students who had access to the survey. The reasons for people declining to participate or agree to participate in surveys vary and are rarely quantified in a way that can be analysed (Groves, Presser, & Dipko, 2004). The online survey, discussed earlier (§ 4.1.3), was first published at the beginning of March during Semester One and then again in early September 2011 during Semester Two at the six universities, as shown in Table 5.1.
Table 5.1  
*Number of survey respondents by university*

<table>
<thead>
<tr>
<th>University#</th>
<th>Number of survey respondents (N = 391)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Semester One</td>
</tr>
<tr>
<td>Sandstone 1 (SS1)</td>
<td>99</td>
</tr>
<tr>
<td>Sandstone 2 (SS2)</td>
<td>35</td>
</tr>
<tr>
<td>Sandstone 3 (SS3)</td>
<td>116</td>
</tr>
<tr>
<td>Technology 1 (TEC1)</td>
<td>30</td>
</tr>
<tr>
<td>Technology 2 (TEC2)</td>
<td>34</td>
</tr>
<tr>
<td>Multi Campus (MCS)</td>
<td>14</td>
</tr>
</tbody>
</table>

# all university names are pseudonyms

Participation in the survey was sought by publishing it on the universities’ websites without any further promotion. Table 5.1 shows that Sandstone 3 was the only university to successfully facilitate student access to the online survey during Semester One. Sandstone 3 repeated the survey in Semester Two when the other universities participated. As a result, almost half of the students came from Sandstone 3. Moreover, four out of five students (80%) were enrolled in one of the three long-established traditional “Sandstone” universities. These large universities have large enrolments in first year mathematics. However the varied response rates for universities related to how widely the survey was published, ethical issues, and the timing of the survey. For example, both SS2 and MCS published the survey one week before their examination period, while MCS had few students enrolled in mathematics.

5.1.2 Types of university courses

Survey respondents were enrolled in a variety of university courses. This information was obtained from responses to Questions 2 and 3 of the survey, which were open response questions asking students to name their university and the course in which they were currently enrolled. Based on their responses to these questions, students were categorised according to course and university. However, these questions were answered inconsistently by students both across and within the six universities. It was, therefore, sometimes
necessary to use personal judgement to choose the closest possible generic title for categories and abbreviations, and also to group different courses under the same name. For example, students enrolled in accounting, commerce, and economics courses were grouped into a major group labelled business, while students enrolled in medicine, surgery and veterinary science were grouped together as medical science. The generic courses and abbreviations that will be used here are: Bachelor of Arts (BA); Bachelor of Business (BBus); Bachelor of Education (BEd); Bachelor of Engineering (BEng); Bachelor of Engineering and Bachelor of Science (BEng/BSc); Bachelor of Information Technology (BIT); Bachelor of Mathematics (BMath); Bachelor of Medical Science (BMedSc); and Bachelor of Science (BSc).

![Bar chart showing percentage of survey respondents enrolled in each university course (N=391).](image)

**Figure 5.1.** Percentage of survey respondents enrolled in each university course (N=391).

The percentage of survey respondents enrolled in each course is shown in Figure 5.1. Almost three-quarters of the respondents (71%) were enrolled in either Science or Engineering or in combined Science and Engineering degrees. The remaining 23% of students who nominated their course were spread across six course groups. Table 5.2 shows the distribution of students’ courses by university.
Table 5.2
Survey respondents’ courses by university (N = 391)

<table>
<thead>
<tr>
<th>Courses</th>
<th>SS1</th>
<th>SS2</th>
<th>SS3</th>
<th>TEC1</th>
<th>TEC2</th>
<th>MCS</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA</td>
<td>5</td>
<td>0</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>14</td>
</tr>
<tr>
<td>BBus</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>BEd</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>0</td>
<td>10</td>
</tr>
<tr>
<td>BEng</td>
<td>11</td>
<td>0</td>
<td>65</td>
<td>13</td>
<td>10</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>BEng/BSc</td>
<td>6</td>
<td>0</td>
<td>21</td>
<td>2</td>
<td>0</td>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>BIT</td>
<td>2</td>
<td>0</td>
<td>5</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>BMath</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>BMedSc</td>
<td>15</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td>BSc</td>
<td>52</td>
<td>25</td>
<td>51</td>
<td>10</td>
<td>0</td>
<td>11</td>
<td>149</td>
</tr>
<tr>
<td>Unknown</td>
<td>3</td>
<td>1</td>
<td>15</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>23</td>
</tr>
<tr>
<td>Total</td>
<td>99</td>
<td>35</td>
<td>179</td>
<td>30</td>
<td>34</td>
<td>14</td>
<td>391</td>
</tr>
</tbody>
</table>

It shows marked differences between the courses being undertaken by these first year mathematics students, based on the university at which they were enrolled. All of the Bachelor of Mathematics (BMath) students came from TEC2, the only university of the six offering such a course, while all of the Bachelor of Arts (BA) students came from either SS1 or SS3. Almost half of the survey participants from SS3 were doing a Bachelor of Engineering (BEng), compared with one third of the total number of participants, with two thirds of all Engineering students participating in the survey coming from SS3. By way of contrast, over 60% of survey participants enrolled in BMedSc came from SS1, which had only 25% of the total survey participants. Also, unlike SS3, less than 20% of students at SS1 were enrolled in engineering degrees. Approximately three quarters of students at both SS1 and MCS (71% and 85% respectively) were enrolled in Bachelor of Science degrees, compared with just 38% of all participants. Of the 24 students who were classified as being enrolled in unknown courses, 15 were from SS3. Most of these either listed a particular subject code or said they were doing the “enhanced program”.

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While these results may indicate different levels of engagement with mathematics subjects in different courses at different universities, they may merely reflect the extent to which the survey was distributed to different cohorts of students.

### 5.1.3 Enrolment in compulsory and elective mathematics subjects

Students who completed the survey may have been enrolled in compulsory or elective mathematics subjects or both. Questions 7 and 8 asked them to give the code of each compulsory and elective mathematics subject or unit that you are enrolled in this semester. In the original survey presented in Semester One to students at Sandstone 3, Questions 7 and 8 asked the students to list the compulsory (Question 7) and the elective (Question 8) subjects that they were taking in the current semester. However, this was revised for the larger Semester Two survey, where the students were asked to list the compulsory and elective subjects for the current year (instead of the current semester). In order to identify each group of students, the Semester One respondents will be referred to as “Group One”, while the Semester Two respondents will be referred to as “Group Two”. Groups One and Two consisted of 116 and 275 students, respectively.

![Graph](image-url)

**Figure 5.2.** Number of compulsory and elective mathematics subjects undertaken by Group One students in Semester One as a percentage of students (N=115).

Figure 5.2 shows the data from Group One students’ responses to Questions 7 and 8. Figure 5.2 shows that 82% of Group One students were undertaking at least one compulsory
subject, while just under a quarter (24%) were undertaking elective subjects. Very few students (just three) were taking four mathematics subjects in their first semester.

Figure 5.3 shows the corresponding data for Group Two students. It shows that a similar percentage (81%) of Group Two student were undertaking at least one compulsory subject, while just over a quarter of Group Two students (27%) were undertaking some elective subjects. The percentage of Group Two students doing four or more mathematics subjects in their first year (44%) was greater than that for Group One (3%). However, it should be noted that the figures for Groups One and Two cannot be compared directly because students surveyed in Semester One were asked about the number of subjects in Semester One only, while those surveyed in Semester Two were asked about the number of subjects in their first year.

![Bar chart showing the number of compulsory and elective mathematics subjects undertaken by Group Two students in their first year as a percentage of students (N=276).](image)

**Figure 5.3.** Number of compulsory and elective mathematics subjects undertaken by Group Two students in their first year as a percentage of students (N=276).

Question 9 asked students whether these subjects or units were the most advanced mathematics that they could have enrolled in this semester. Three options were offered: *all at the most advanced level*, *some at the most advanced level*, and *none at the most advanced level*. Responses from the 365 students who answered this question showed that 45% of students stated that all of their mathematics subjects were at the most advanced level. However, these results are not reliable as different students frequently classified the
same subjects differently. For example, S58 and S59 (student numbering is by survey completion order), who were both taking the same single mathematics subject MATH1501, gave different responses, with S58 answering “all advanced” and S59 “none advanced”. Due to these different responses, no further analysis was carried out based on responses to this question.

5.1.4 Mathematics sequences

Question 14 asked students to rate statements regarding their intention to take further compulsory mathematics subjects, further elective mathematics subjects, mathematics minor or mathematics major as “Definitely not”, “Probably not”, “Probably”, or “Definitely”. Based on their responses, students were placed into four groups: Major (MM), Minor (MN), Elective (EM), and Compulsory (CM) mathematics. The responses to this question were reduced to a positive or a negative response (i.e. “Probably” and “Definitely” were both taken as a positive response and “Definitely not” and “Probably not” taken as a negative response). Students were classified using the following procedure. Firstly, students who responded positively to intending to undertake a mathematics major were classified as MM (see below) and excluded from the remaining classification process. Secondly, remaining students who responded positively to intending to undertake a minor study in mathematics were classified as MN and excluded from the remaining classification process. Next, students who indicated that they were either enrolled in elective first-year mathematics subjects, or who responded positively to intending to undertake elective mathematics subjects in the future, were classified as EM. Lastly, all remaining students were classified as CM – that is as undertaking compulsory mathematics subjects only. The total number of students in each group is shown in the list below:

MM – Students intending to complete a major in mathematics (n = 87).
MN – Students intending to complete a minor, but not a major, in mathematics (n = 43).
EM – Students currently undertaking or intending in the future to undertake elective mathematics, but not intending to complete a major or minor (n = 107).
CM – Students intending to complete only compulsory mathematics (n = 154).
5.1.5 Choice of university course

Questions 4, 5 and 6 asked students about their choice of university course. Question 4 asked students whether their current university course was their first choice. Question 5 asked those students for whom their current university course was not their first choice what university course had been their first choice. Question 6 asked these students why they thought they missed out on their first choice.

A total of 59 students (15%) indicated that they missed out on their first choice. Figure 5.4 shows the percentage of students who missed out on their first choice of course by current course enrolment.

![Figure 5.4. Percentage of students enrolled in first and later choices of course by current course enrolment (N=391).](image)

As can be seen in Figure 5.4, the courses that had the largest percentage of students (29% in each) not enrolled in their first choice of course were the Bachelor of Medical Science (BMedSc) and the Bachelor of Arts (BA) students, followed by the Bachelor of Information Technology (BIT) students (25%). While the number of students in these courses were small, 30 of the 149 Bachelor of Science (BSc) students who answered this question (20%) indicated that this was not their first choice of course. At the other end of the spectrum, just one student of the 20 students (5%) in the Bachelor of Mathematics (BMath) and one of the 10 students (10%) in Bachelor of Education (BEd) were not enrolled in their first choice of course. A small percentage of students (7%) enrolled in the single Bachelor of Engineering (BEng) course were also not in their first choice of course.
Table 5.3 displays the first choice of courses for those students who missed out on their first choice. Table 5.3 shows that the majority of respondents who missed out on their first choice had wanted to do a Bachelor of Medicine/Bachelor of Surgery (MBBS), with 33 students (56%) naming this as their first choice. The next most frequently missed first choice was the Bachelor of Science Advanced course, BSc (Adv), which had been the first choice for 8 students (14%). Over a third of all students (37%) who reported missing out on their first choice of course (22 of the 59) nominated one of these courses as their first choice and had subsequently enrolled in a Bachelor of Science (BSc) course.

<table>
<thead>
<tr>
<th>Current Course</th>
<th>BBus</th>
<th>BEng</th>
<th>BEng/ BSc</th>
<th>BMedia</th>
<th>MBBS</th>
<th>BSc (Adv)</th>
<th>Others</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>BEd</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
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Students’ responses to Question 6 show that a high university entry requirement was the reason most often given by students for missing out on their first choice (72%). Some other students blamed low school results (17%), giving a total of 89% of students stating that the reason they missed out on their first choice was that they did not meet the entry score cut-offs. About 5% of students stated that they changed their mind during the admission process and changed their first choice of course. Other reasons given by the remaining 6% of students for not being admitted to their first choice of course included being sick, having family problems, or simply being relaxed or negligent during senior secondary school. For example, S267 stated that “lack of motivation, having no desire to do
work [and] chronic procrastination” were reasons for his failing to be accepted into his first choice of course.

In summary, survey participants came from six universities in three Australian states. Almost half of the students were undertaking a degree in Science or a combined degree in Science and Engineering, with a further quarter of the students enrolled in a single course in Engineering. Approximately 22% of the survey respondents were planning to undertake a major in mathematics, with a further 11% planning to undertake a minor. Almost 40% of students were only intending to study compulsory mathematics, with the remaining 27% taking some elective mathematics.

5.2 Factors influencing students’ choice of mathematics

A primary aim of this study was to determine the factors that influence students’ choice of mathematics at university. This was explored in Questions 1, 12 and 13, which broadly asked the students to indicate their motivation for enrolling in mathematics subjects at university. Question 1 was an open response question about the factors that influenced students’ choice of mathematics at university. Question 12 was a multiple-choice question listing factors that were originally gathered from the literature (Forgasz, 1998; Heiat et al., 2007; Lyon & Quinn, 2007) as well as allowing students to nominate other factors. Question 13 asked students to select the most important factor from those they listed in Question 12.

5.2.1 Reasons nominated by students for choosing university mathematics

Question 1 asked students to comment on the factors you think have influenced your choice of mathematics subjects or units at university. This question was asked at the beginning of the survey when participants were not tired or influenced by their responses to other survey questions. Another reason for introducing the survey with an open question was to obtain students’ ideas in their own words without introducing bias or influence from the wording of the survey questions.

Where possible, responses to Question 1 were classified according to the factors used in Question 12. However, students included factors not listed in Question 12 – namely
the use of mathematics in their later careers (8% of students) and parental interest in mathematics (2% of students).

When answering Question 1, many students mentioned more than one factor. Therefore the results given in this section include all of the answers given. Figure 5.5 shows the percentage of students nominating different factors as having influenced their choice of mathematics, with the two most influential factors in choosing mathematics nominated by these first-year university students being Enjoyment and Part of course, with both of these being nominated by 43% of students. The next most influential factor nominated by students was Maths experience (16%), closely followed by Did well in maths at school (14%).

The factor Maths experience included comments such as students having had supportive school staff, an approachable teacher, or a friendly class environment. This was regarded as a different factor from Did well in maths at school. Students who nominated Did well in maths at school were students who gave details about their ability in school mathematics and stated that they had obtained good grades. Most claimed that they liked to put effort into excelling in mathematics, although some referred to their easy progress as being due to having “mathematics ability” or natural “power” in understanding the subject.

![Figure 5.5. Percentage of students nominating different factors that influenced their choice of mathematics (N= 381).](image)

Further analysis of the influential factors nominated by students included categorising responses according to the Expectancy Value Theory of Motivation (Eccles et
al., 1998) – see §4.2.4. However, the motivation for undertaking a particular task is often complex and multifaceted, with more than one type of value often being considered and weighed up against the costs and other opportunities. Furthermore, statements sometimes suggested more than one type of value often being considered and weighed up against the costs and other opportunities, while at other times not enough information was provided to confidently categorise a statement, and the categorisation was necessarily based on assumptions. Some examples of responses under the different categories are given below.

**Intrinsic value**

*Enjoyment*, which together with *Part of course*, was the factor nominated by the greatest percentage of students (43%), is viewed by Eccles et al. (1998) as either the result of *situational interest* – that is the outcome of performing a task for its innate characteristics – or *personal interest* in engaging in a task. Thus statements about the influence of situational interest or personal interest were interpreted as *intrinsic value*.

Enjoyment that resulted from performing a task – situational interest – was demonstrated by the following student who enjoyed solving mathematics problems. He said:

> What drives me to study mathematics is the enjoyment I get out of solving a problem. The feeling of getting to the end of it and being able to say that was hard but I can do it (S75, Q1).

This quote is an example of a multifaceted case where the students’ enjoyment of mathematics is also related to their personal achievement and self-identity, suggesting that it could also be classified under attainment value.

A similar multifaceted example of *Enjoyment* came from a student who saw himself as having inherent ability in mathematics, contributing to his expectation of success, as well as showing his personal interest in becoming engaged with the field of mathematics contributing to the attainment value of studying mathematics:

> I find mathematics an incredibly interesting field of study and one that comes very naturally to me. When I discovered that not only do many employers hire mathematicians but that one can work as a research mathematician I then decided that, without question, I was going to study mathematics at university (S81, Q1).
In a similar way, *Enjoyment* was embedded as an influential factor in different responses to the survey.

**Utility value**

Utility value is accrued through tasks that help to facilitate long-term goals or that help to obtain benefits that are external to the task itself (Wigfield & Eccles, 2000; Eccles, 2009a).

*Part of course* was regarded as being associated with utility value because the motivation for enrolling in the subject was assumed to be external to the intrinsic benefits of the subject itself, instead relating to the goal of completing the course. In many instances students indicated that they were studying mathematics subjects to fulfill the requirements of their selected course. For example, one student stated:

The mathematics subjects I’ve done so far have been core subjects, so really my course is what has influenced the actual subject (S158, Q1).

The decision to take the course in the first place could be motivated by other values. This was evident in the survey data where some students (S31, S56, & S81, Q1) who indicated that their course selection was based on enjoyment of mathematics also indicated that their choice of mathematics subjects was based on course requirements.

These are examples of the difficulties encountered in categorising short answer responses to items where motivational factors can be linked to different types of value and the complexity of prioritising types of value therefore becomes more challenging.

Another student, who planned to major in physics, found mastering mathematics to be important not only as a course requirement but also because the skills would service other areas:

Mathematics is a compulsory unit in the Physics major. Also, it struck me one day that mathematical illiteracy is just as serious an impairment as English illiteracy, so I decided to put serious effort into strengthening my mathematical ability (S65, Q1).

Another source of utility value was *Use in later career*. For example, one student explained the importance of a mathematics background in obtaining quality employment in his primary field of business:
Work, I have a business degree and it is not good enough to get a job in business, a mathematics based degree is something that is often looked for and is considered more important in certain financial firms (S29, Q1).

While the factor *Maths experience*, selected by 16% of students, would not usually be associated with utility value, some students aimed to use their knowledge to improve their grades, which can also be seen as utility value. An example is given below:

I enjoyed mathematics subjects in high school and thought it would not only be a way to fill up an empty unit space, but also be a good decision because I find maths quite an easy subject and thought I would be able to achieve good results (S318, Q1).

Another aspect of utility value appeared in comments such as “Salary after degree and market demand for math graduates appears high” (S126, Q1) and “It is essential for my preferred job/career” (S138, Q1), where students indicated that their motivation for taking mathematics subjects was related to rewards and opportunities that would come later.

*Attainment value*

Attainment value relates to an individual’s self-image – about who they are and what they would like to be. This is builds as they mature, and is linked to their personal value in doing a task well, which confirms the salient aspects of their self-schema (Wigfield & Eccles, 2000; Wigfield et al., 2006; Eccles, 2009b).

An example of the link between tasks, self-image, and preferences was expressed by a student whose positive mathematics experience at school inspired him to pursue a career in mathematics. This can be related to attainment value as seen in the following statement:

Mathematics is my primary academic pursuit and always has been since a very early age. Extending my knowledge in the field was an opportunity I wanted to pursue for many years before starting my tertiary education (S127, Q1).

Other factors relating to attainment value (Eccles, 2009a), such as *Peer influence* (relevant for suitable behaviour in society) and *Parental interest* (relating to schema of individuals’ roles in their culture group), were mentioned by very few students. Examples of these includes “Family interest” (S12, Q1) and “interests of my peers” (S280, Q1). These factors have been shown to be of significant influence in previous research, mostly relating to school rather than university (e.g. Savin-Williams & Berndt, 1990; Ma, 2001; Sheldon,
2002; Wentzel, 2005; Awad, 2008: Wu, 2009; Miller, 2010), but did not feature strongly in
the survey data.

Students who are passionate about mathematics often see themselves in a career
that requires and utilises mathematical knowledge in their future lives. This is different from
students who do mathematics just because it is part of their university course. Strong
interest linked to attainment value takes time to develop for some students, as can be seen
in the following example from a student who was doing the double degree Bachelor of
Medical Science/Bachelor of Engineering, who also noted the utility value associated with
career options:

I love mathematics and wasn’t sure what I wanted to do after I finished VCE.
Mathematics was something I enjoyed, and the fact that mathematics can lead to all
kinds of different careers was appealing. It offered me a few more years to decide
what I want to do (S326, Q1).

As suggested by Eccles (2009b), as individuals mature they develop an ideal image of
what they want to be in terms of their long term plans and goals, their capabilities and
personality, and their social behaviour characteristics.

Cost value

Eccles and Wigfield (2002) define cost value as the negative side of engaging in an
activity “such as performance anxiety and fear of both failure and success, as well as the
amount of effort needed to succeed and the lost opportunities that result from making one
choice rather than another” (p. 120). Cost could also be considered as loss of money, time
or energy for engaging in other applications (Eccles, 2009a).

Cost value was not nominated as an influential factor in enrolling in university
mathematics by students responding to Question 1 in the survey.

Expectation of success

Theories related to students’ beliefs in their competency, efficacy, sense of control
(Bandura, 1997) and their expectation of success relate to beliefs in self-capability in
selecting and performing a task and being motivated towards doing that task (Eccles &
Wigfield, 2002). Eccles (2009b) explains that expectation of success relates to individuals’
self-perceptions of their characteristics, skills and competence.
Data obtained from Question 1 showed that 14% of students selected mathematics based on their belief in their ability to do well in mathematics. For example, student S185 said: “I have always found it easier than any other subject, and for that reason I enjoy it.”

Another student, who was successful at secondary school mathematics, believed in his mathematical ability and was interested in the subject, but also believed that mathematics was important for his future career and enhanced employability, noting:

My experiences with mathematics at high school. My abilities with mathematics. A general interest in the subject. The fact there is a skills shortage in Australia for maths. (S371, Q1)

This combining of statements about ability and statements about value can also be seen in the next example:

Mathematical ability, enjoyment of studying mathematics, prerequisites for subjects to be taken later in my course and/or post-graduate education. (S345, Q1)

As can be seen in these two examples, enjoyment of mathematics (Intrinsic value) is often linked with positive self-assessments of mathematical ability and can also feature as a component in Attainment value where individuals see themselves as mathematically able people.

### 5.2.2 Reasons selected by students for choosing university mathematics

Factors influencing students’ choice of mathematics at university were explored again in Question 12, a multiple-choice question. In this question, students were asked to select from a list of factors suggested by the literature review (Forgasz, 1998; Heiat et al., 2007; Lyon & Quinn, 2007). A key difference between Question 1 and Question 12 is that Question 1 asked about the factors influencing students’ choice of mathematics at university while Question 12 asked why they chose mathematics subjects in the current semester (or year). Question 12 also gave specific options for the respondents to select, whereas Question 1 was completely open.

Specifically, Question 12 asked students: What were the main reasons for your choice of mathematics subjects or units in this semester [year]? Students could select one or more of the following reasons: They are part of my course or program; I did well in maths at
school; I want to learn more about maths; I enjoy maths; Mastery in maths is important in my course or program; and I am following my peers or friends.

Students could also nominate other factors if they wished, so the percentages relate to the number of responses identifying each reason as being influential in their choice of mathematics. Therefore the total for the percentages shown in Figure 5.6 is greater than 100%.

![Figure 5.6: Percentage of students selecting different factors that influenced their choice of mathematics (N= 360).](image)

As can be seen in Figure 5.6, Part of course was selected as the reason for choosing mathematics subjects in the current year of university by the highest percentage (85%) of students. The next most frequent reasons selected were Did well in maths at school (61%) and Enjoyment (60%).

However, 60% of the students who selected Part of course also selected Enjoyment, the same percentage as overall. The factor Did well in maths at school was also selected by 83% of students who chose the factor of Enjoyment. Therefore, enjoyment of mathematics appears to be related to mathematics achievement at school, as discussed above (§ 5.1.3).

The factor Peer influence was selected by only 3% of students, with 8% of students nominating other factors such as: “study related reasons” (6%) and “future career related reasons” (2%).

Neither the category Prerequisite nor Use in later career was provided in the multiple choice question lists as it did not feature in the literature reviewed. About a third of the
students who selected *Other* were doing a mathematics subject as a prerequisite, for example:

> It is a prerequisite for a science degree (S74, Q12)

> Or they were doing the subject to help in a future career or to improve their employability. The following quotes illustrate the way in which future career prospects (*Utility value*) discussed earlier dominated the minds of some students:

> The skills will most likely be important in the future for my career (S155, Q1).

> I can see myself carrying out a career in this field later. Not much else really appealed to me (S126, Q12).

> I want a high paying job and I believe (possibly erroneously) that maths will help me achieve it (S381, Q12).

> Another respondent chose *Other* because she believed a knowledge of mathematics would make her more employable as well as give her enjoyment:

> As a musicologist, I am looking for a new career that involves the things I enjoy about music theory that will make me more employable. So far, I find mathematics is similar to what I enjoyed most about musicology (S374, Q12).

Further examples of the choice of *Other* can be seen in the following quotes:

> My father gives me money this way (S344, Q12)

> [I] wanted to choose a variety of study areas as possible (S247, Q1).

The next question, Question 13, asked students: *If you ticked more than one box in the previous question, which of the above was the most important reason for your choice of mathematics?* Data from the responses to Question 13 were combined with data from students who nominated just one factor in Question 12 to provide the data for Figure 5.7.
Figure 5.7. Percentage of students selecting different factors as the most influential in their choice of mathematics (N= 342).

Again, as was the case for Question 12, the most frequently selected reason given for choosing mathematics subjects was Part of course, with just over half of the students selecting this as the most influential factor. Less than a third of students gave Enjoyment as the most influential factor in their choice of mathematics subjects, with Learning more and Mastery in the subject being selected by fewer than 10% of students in each case. Surprisingly the factor Did well in maths at school, although selected by 61% of the respondents in Question 12, was only selected as the most important factor by 4% of students.

However, as was the case with responses to Question 12, there was often a close link between enjoyment of mathematics and the fact that it was Part of course, as shown in the next example:

The fact that mathematics courses are compulsory for the mathematics major would be the most essential reason, but the fact that I enjoy mathematics is the main reason I'm majoring in mathematics in the first place (S18, Q13).

In another example a student admits that enjoyment of mathematics directed her towards her course where mathematics is a “part of that course”:

I guess "they are a part of my program" but I wouldn't have chosen engineering if I didn't enjoy maths (S181, Q13).

Links between choosing university courses and students’ interest or enjoyment mentioned in this study have frequently been highlighted in the findings of previous studies (Marks et al., 2001).
5.2.3 Relationships between students’ courses and influential factors

Data collected from Question 1, which gave respondents the opportunity to use their own words to express the factors they believed influenced their choice of mathematics subjects at university, were examined in more detail taking into account the courses in which the students were enrolled.

In order to have a sufficient number of responses in each category when carrying out this analysis, some of the categories of responses were collapsed as follows. The factor Prerequisite was combined with Part of course by including all students who nominated either or both of these factors. A new category, High school experience, was created by combining Maths experience with Did well in maths at school – that is, by including all students who nominated either or both of these factors. Factors nominated by a very small percentage of students – Use in later career, Peer influence and Parental interest – were omitted from this analysis.

Courses offered by the same faculty or having common subjects were also combined as follows: Bachelor of Information Technology (BIT) was incorporated with the Bachelor of Business (BBus); Bachelor of Education (BEd) was incorporated with the Bachelor of Mathematics (BMath); while both the Bachelor of Medical Science (BMedSc) and the double degree of Bachelor of Engineering and Bachelor of Science (BEng/BSc) were subsumed into the Bachelor of Science (BSc).

Figure 5.8 shows the results of this analysis. As can be seen, the different student cohorts exhibited different patterns in their identification of factors influencing their choice of mathematics at university. Over three quarters of students enrolled in the Bachelor of Mathematics nominated Enjoyment as a factor influencing their choice of mathematics, compared with just over 40% of students from the other four cohorts. Only 10% of these students nominated Part of course, compared with between half and almost three quarters of students in the other cohorts. The Bachelor of Mathematics students were also the most likely to nominate High school experience as a factor influencing their choice. These results are not surprising, given that these students have chosen to do a course that commits them to undertake a mathematics major as part of their course.
Figure 5.8. Percentage of students nominating different factors that influenced their choice of mathematics, by course (N =361).

Overall, the pattern of factors nominated by the other four cohorts of students is similar with Bachelor of Engineering students most likely to nominate Part of course and Bachelor of Science students least likely to do so. Among these four cohorts, Bachelor of Science students were the most likely to nominate High school experience, while Bachelor of Arts students were the least likely to do so.

In order to test the statistical significance of the different patterns between different student cohorts, statistical tests were conducted. The results of the tests were classified as "highly significant" when $p < 0.001$ and "significant" when $p<0.01$ or $p<0.05$. For clarity the significance level is stated for each test.

Firstly, Pearson’s chi-square test was conducted. This chi-square test is a statistical test used to compare the observed data with expected data with respect to a specific hypothesis. The null hypothesis is that there is no significant difference between the expected and the observed results (Fisher & Yates, 1974; Carter & Carter, 1999). Pearson’s chi-square test identifies the degree of association between variables (Shana & Venkatachalam, 2011).

The $p$-value resulting from a chi-square test is the probability that the any differences of the observed values from the expected is due to chance alone. So, using $p < 0.001$, you would expect any differences due to chance alone to occur less than once in 1000 times or less (Fisher & Yates 1974; Carter & Carter 1999; Shana & Venkatachalam, 2011). That is, a value of $p < 0.001$ (a value often used in educational research to indicate a
high level of statistical significance) means there is less than one chance in a thousand of stating that there is a difference when, in fact, there is no significant difference. This means the null hypothesis is rejected, and the association is significant. Here, a $p$-value of $p < 0.001$, would indicate that there is a statistically significant relationship between factors influencing the choice of mathematics at university and the courses in which students are enrolled.

Pearson’s chi-square test was used on the data shown in Figure 5.8, resulting in a $p$-value less than 0.01 ($\chi^2 = 30.019$, $df = 12$, $p = 0.003$) indicating that there is a statistically significant relationship between factors influencing the choice of mathematics at university and the courses in which students are enrolled.

While Pearson’s chi-square test indicated here a statistically significant relationship, it does not identify where the differences lie. Moreover, the fact that students often listed multiple factors means that the chi-square test was carried out based on frequencies of responses rather than of students. A further test, a pair wise test on proportions of students, the $z$-test, was therefore carried out on the selected factors. A $z$-test is used when we want to know whether two populations differ significantly on some single characteristic – for example here on the proportion of students nominating Enjoyment as a factor influencing their choice of mathematics.

The results from the $z$-tests showed a highly significant difference ($p<0.001$) for the high proportion of Bachelor of Mathematics students nominating the factor of Enjoyment when compared with the Bachelor of Engineering and Bachelor of Science students, and a significant difference ($p<0.05$) when compared with the Bachelor of Arts and Bachelor of Business students. The $z$-tests also showed a highly significant difference ($p<0.001$) for the low proportion of Bachelor of Mathematics students nominating the factor of Part of course when compared with each of the other four cohorts. Similarly, there was a highly significant difference ($p<0.001$) between the proportion of Bachelor of Engineering and Bachelor of Science students nominating the factor of Part of course. No other statistically significant differences were found, indicating that while the differences in proportions of students nominating High school experience may appear quite different, there is no evidence that these differences are statistically significant.
As can be seen in §5.2.1 and §5.2.2, students’ responses regarding factors influencing their choice of mathematics subjects at university were different for Question 1 (open-response) and Question 12 (multiple-choice).

Data collected from Question 12 were also examined in more detail taking into account the courses in which the students were enrolled. For the purposes of this analysis, courses were combined in the same way as for Question 1, and the factor *Prerequisite* was combined again with *Part of course*. In this case, however, there is no combined category *High school* experience, as the multiple-choice Question 12 only allowed students to select *Did well in maths at school*. Also, due to the relatively high percentage of students who selected *Learning more* and *Mastery in subject*, both of these categories are included here. *Peer influence*, which was again nominated by a very small percentage of students, was omitted from this analysis, while the other three categories of *Use in later career, Parental interest* and *Expectation of success* were not given as options to select.

![Bar chart](image)

*Figure 5.9. Percentage of students selecting different factors that influenced their choice of mathematics, by course (N =341).*

As Figure 5.9 shows, the different student cohorts again exhibited different patterns in their selection of factors influencing their choice of first-year mathematics subjects at university, with more than 90% of Bachelor of Mathematics students selecting each of the factors *Enjoyment, Part of course, Did well in maths at school, and Learn more*, while over 60% selected *Mastery*. For the Bachelor of Engineering, Bachelor of Science, and Bachelor of Business students, *Part of course* was the factor most often selected. However, *Enjoyment*
was also strongly endorsed by students undertaking these courses, with almost 60% of these students selecting this factor. By way of contrast, the Bachelor of Arts students selected the factor *Learn more*, most often with only just over a third of these students selecting *Enjoyment*.

A Pearson chi-square test was carried out to compare the data from the different cohorts of students. The results showed no statistically significant relationship between the factors influencing students’ choice of mathematics and the courses in which they are enrolled ($\chi^2 = 14.726, df = 16, p = 0.547$).

While the chi-square test showed no statistically significant overall result, the proportion of Bachelor of Mathematics students selecting different factors appeared to be quite different than for students in the other cohorts. A pair-wise z-test, was therefore carried out again on selected factors. The results from the z-tests showed a highly significant difference ($p<0.001$) for the proportion of Bachelor of Mathematics students selecting the factor of *Enjoyment* when compared with the Bachelor of Arts, Bachelor of Engineering and Bachelor of Science students, and a significant difference (at the $p<0.01$ level) when compared with Bachelor of Business students. The results also showed a highly significant difference ($p<0.001$) for the proportion of Bachelor of Mathematics students selecting the factor of *Learn more* when compared with the Bachelor of Business, Bachelor of Engineering and Bachelor of Science students, and a significant difference ($p<0.01$) when compared with the Bachelor of Arts students. In addition, there was a significant difference ($p<0.01$) between the proportions for Bachelor of Mathematics students selecting the factor of *Did well in maths at school* when compared with the Bachelor of Business, Bachelor of Engineering and Bachelor of Science students.

Results from the z-tests also showed a highly significant difference ($p<0.001$) for the proportion of Bachelor of Arts students selecting both of the factors *Part of course* and *Did well in maths at school* when compared with the Bachelor of Mathematics, Bachelor of Engineering and Bachelor of Science students, and a significant difference ($p<0.05$) when compared with Bachelor of Business students.

Data from the responses to Questions 13 and 12, where appropriate, were examined again taking into account the courses in which students were enrolled.
Figure 5.10. Percentage of students selecting factors that most influenced their choice of mathematics, by course (N =325).

Figure 5.10 shows the data for this analysis. As can be seen, the different student cohorts again exhibited different patterns in their identification of the factor most influencing their choice of first-year mathematics subjects at university, with two-thirds of Bachelor of Engineering students selecting Part of course, while almost 60% of Bachelor of Mathematics students selected Enjoyment. Part of course was also the factor most frequently selected by the Bachelor of Arts, Bachelor of Business and Bachelor of Science students, while the Bachelor of Arts students were approximately three times as likely to select Learn more than the other students.

Due to the smaller number of responses, it was not possible to carry out a chi-square test as more than 20% of the expected counts were less than 5. Results from conducting z-tests (and Student t-tests for cases when the sample sizes were less than 30) showed a highly significant difference for the proportion of Bachelor of Mathematics students selecting the factors Part of course and Enjoyment when compared with the Bachelor of Engineering students (p<0.001), and a significant difference for these factors when compared with the Bachelor of Science students (p<0.01). The proportion of Bachelor of Engineering students selecting these two factors also showed a significant difference when compared with the Bachelor of Science students (p<0.05). No other statistically significant differences were found.

In summary, the different student cohorts exhibited different patterns in their identification of factors influencing their choice of mathematics at university, with the
Bachelor of Mathematics students most likely to nominate and select *Enjoyment* as a factor influencing their choice of university mathematics, while the Bachelor of Engineering students were most likely to nominate and select *Part of course*. This pattern was repeated when students were asked to select the factor that most influenced their choice, where again the highest percentage of Bachelor of Mathematics students selected *Enjoyment*, while the highest percentage of the remaining four cohorts selected *Part of course*.

### 5.2.4 Relationships between mathematics sequences and influential factors

Data collected from Question 1 were again examined in more detail taking into account students’ mathematical sequences (see § 5.1.4). As was the case when analysing students’ responses to Question 1 according to the course in which they were enrolled (§ 5.2.3), in order to have a sufficient number of responses in each category, some of the categories of responses were collapsed. In particular, the factor *Prerequisite* was again combined with *Part of course* by including all students who nominated either or both of these factors; the category *High school experience*, earlier created by combining *Maths experience* with *Did well in maths at school* was used again; and factors nominated by a very small percentage of students – *Peer influence* and *Parental interest* – were omitted from this analysis. However, in this case *Use in later career* was retained as the number of students in each of the categories for mathematical sequences was larger than for the different courses.
Figure 5.11. Percentage of students nominating different factors that influenced their choice of mathematics, by mathematics sequence (N=381).

Figure 5.11 shows the data for this analysis. As can be seen, the different student groups again exhibited different patterns in the factors they nominated as influencing their choice of mathematics at university. Three quarters of students planning to undertake a major in mathematics (MM) nominated *Enjoyment* as a factor influencing their choice of mathematics, compared with approximately half of those planning to undertake a minor (MN) in mathematics or take elective mathematics (EM) subjects, and less than a quarter of those only taking compulsory mathematics (CM) subjects. Not surprisingly, almost 80% of students who were only taking compulsory mathematics subjects nominated *Part of course*, compared with under a half of those planning to undertake a minor in mathematics or take elective mathematics subjects, and less than 20% of those planning to undertake a major in mathematics. Students planning to undertake a major in mathematics were twice as likely as those planning to undertake a minor in mathematics or take elective mathematics subjects to nominate *High school experience* as a factor, and almost five times as likely as those only undertaking compulsory mathematics. Those students who were planning a major in mathematics were also much more likely to nominate *Use in later career* as a factor.

Pearson’s chi-square test was used again on the data shown in Figure 5.11, resulting in a p-value less than 0.001 indicating that there is a highly statistically significant
relationship between factors nominated by students as influencing their choice of mathematics at university and students’ planned mathematics sequences.

As was the case for the analysis of the data shown in Figure 5.8, a further pair-wise z-test on proportions of students was carried out on selected factors. The results from the z-tests showed a highly significant difference ($p<0.001$) for the proportion of students only taking compulsory mathematics subjects nominating both of the factors *Enjoyment* and *Part of course* when compared with the other three groups, and a similar highly significant difference between those planning to undertake a major in mathematics when compared with those taking elective mathematics subjects, and a significant difference ($p<0.01$) for these mathematics major students when compared with those planning to undertake a minor in mathematics. In terms of their nomination of *Enjoyment* and *Part of course* as factors, there was no statistically significant difference between students planning to undertake a minor in mathematics and those taking elective mathematics subjects. There was again a highly significant difference ($p<0.001$) between the proportion of students only taking compulsory mathematics subjects nominating the factor *High school experience* compared with students planning to undertake a major in mathematics, and a significant difference ($p<0.05$) when compared with students planning to undertake a minor in mathematics or take elective mathematics subjects. The only other statistically significant difference was between the proportion of students planning to undertake a major in mathematics nominating *Use in later career* and those only taking compulsory mathematics subjects ($p<0.001$), those elective mathematics subjects ($p<0.01$), and those planning to undertake a minor in mathematics ($p<0.05$).

Data collected from Question 12 were also examined in more detail taking into account students’ mathematical sequences.
Figure 5.12. Percentage of students selecting different factors that influenced their choice of mathematics, by mathematics sequence (N=360).

Figure 5.12 shows the data for this analysis. As can be seen, the different student groups again exhibited different patterns relating to the factors they selected as influencing their choice of mathematics at university. While only a third of students taking only compulsory mathematics subjects selected *Enjoyment* as a factor influencing their choice of mathematics at university, between 60% and 92% of the other groups selected this fact, with students planning to take more mathematics subjects more likely to select *Enjoyment* as a factor. More than three quarters of all students selected *Part of course* as a factor, with (not surprisingly) 99% of those students taking only compulsory mathematics subjects selecting this factor. In terms of the remaining factors, there was very little difference between students planning to undertake a minor in mathematics and those taking elective mathematics subjects. However, approximately twice as many students planning to undertake a mathematics major selected *Did well in maths at school* and *Mastery* as did those students taking only compulsory mathematics subjects. The difference between these two groups was even more pronounced in terms of the factor *Learn more*, with 86% of students planning to undertake a major in mathematics selecting this as a factor compared with only 13% of those students taking only compulsory mathematics subjects.

Pearson’s chi-square test was used again on the data shown in Figure 5.12, resulting in a *p*-value less than 0.001 ($\chi^2 = 1788.616$, $df = 12$, $p = 0.000$) indicating that there is a
statistically significant relationship between factors selected by students as influencing their choice of mathematics at university and students’ planned mathematics sequences.

As was the case previously, a further pair-wise z-test on the proportions of students was carried out on selected factors. For all factors, the results from the z-tests showed no statistically significant differences between the proportions of students planning to undertake a minor in mathematics when compared with those taking elective mathematics subjects. However, the results from the z-tests showed a highly significant difference ($p<0.001$) for the proportion of students only taking compulsory mathematics subjects nominating this factor, when compared with the other three groups, with no other statistically significant differences. For the factor *Did well in maths at school*, there was a highly significant difference ($p<0.001$) for the proportion of students planning to undertake a major in mathematics selecting this factor, when compared with those only taking compulsory mathematics subjects, and a significant difference when compared with the other two groups ($p<0.01$). There was also a significant difference between those only taking compulsory mathematics subjects and those taking elective mathematics ($p<0.01$) and those planning to undertake a minor in mathematics ($p<0.05$). The factor *Learn more* showed the biggest difference with all pair-wise comparisons (except between those planning to undertake a minor and those taking elective mathematics subjects) showing a highly significant difference ($p<0.001$). For the factor *Mastery*, there was again a highly significant difference ($p<0.001$) between the proportion of students only taking compulsory mathematics subjects selecting this factor, when compared with those planning to undertake a major in mathematics, and a significant difference ($p<0.01$) when compared with the other two groups. The only other statistically significant result for this factor was between those students planning to undertake a mathematics major and those taking elective mathematics subjects ($p<0.05$).

Data from the responses to Questions 13 and 12, where appropriate, were re-analyzed taking into account students’ mathematics sequences. Figure 5.13 shows the data for this analysis.
As can be seen, the different student groups again exhibited different patterns in their identification of the factor most influencing their choice of first-year mathematics subjects at university, with 93% of students only taking compulsory mathematics subjects selecting *Part of course*, compared with just 12% of students planning to undertake a mathematics major. Almost two thirds of this latter group selected enjoyment, compared with just 2% of those only taking compulsory mathematics subjects. As was the case earlier, there was much less difference between the pattern of responses for students planning to undertake a minor in mathematics and those taking elective mathematics subjects.

Due to the number of responses, it was again not possible to carry out a Pearson chi-square test, as more than 20% of the expected counts were less than 5. Results from conducting pair-wise z-tests showed a highly significant difference for the proportion of students only taking compulsory mathematics subjects nominating *Part of course*, when compared with the other three groups (*p*<0.001), and a similar highly significant difference between those planning to undertake a major in mathematics, when compared with those taking elective mathematics subjects (*p*<0.001), and a significant difference for these mathematics major students, when compared with those planning to undertake a minor in mathematics (*p*<0.01). For the factor *Enjoyment*, there was a highly significant difference between those planning to undertake a major in mathematics, when compared with those taking elective mathematics subjects (*p*<0.001), and a significant difference for these
mathematics major students, when compared with those planning to undertake a minor in mathematics \( p<0.01 \). The only other statistically significant difference was between the proportion of students taking elective mathematics subjects and those students only taking compulsory mathematics subjects selecting the factor \textit{Mastery} \( p<0.01 \).

In summary, the different groups of students exhibited different patterns in their identification of factors influencing their choice of mathematics at university, with those students who were planning to undertake a major in mathematics most likely to nominate and select \textit{Enjoyment} as a factor influencing their choice of university mathematics, while those students who were only taking compulsory mathematics subjects were most likely to nominate and select \textit{Part of course}. This pattern was repeated when students were asked to select the factor that most influenced their choice, where, again, the highest percentage of students planning to undertake a major in mathematics selected \textit{Enjoyment}, while the highest percentage of the remaining three groups selected \textit{Part of course}.

\textbf{5.2.5 Factors influencing students’ choice of further elective mathematics}

The open response Question 15 looked for reasons behind students’ plans to take further elective mathematics by asking them: \textit{If you are planning to do further elective mathematics subjects or units at university (including a minor or major), what are the main reasons for your choice?} Although the purpose of the question was to discover the reasons for planning to take further elective mathematics, and was not designed to ask about influential factors directly, the responses were categorised using the same classification as applied to Questions 1 and 12, but with fewer categories due to the range of participant responses. The categories used were \textit{Enjoyment}, \textit{Part of course}, \textit{Use in later career}, \textit{Mastery in subject}, \textit{Learning more}, \textit{Use in other subjects}, \textit{Did well at school}, and \textit{Other} (see Figure 5.14).
Figure 5.14. Percentage of students nominating different reasons for planning to take elective mathematics subjects (N= 176).

Given the results reported in § 5.2.4, it is not surprising that *Enjoyment* was the reason most frequently given by students for undertaking elective mathematics, with almost half of these students nominating this as a reason – more than twice the number for any of the other categories of response. For example, one student stated:

The mathematics subject looks more interesting than the other option for my elective (S256, Q15).

The other results are also consistent with the findings from § 5.2.4. For example, while only 8% of all students nominated the factor *Use in later career* in Question 1 (see Figure 5.5), 21% of students planning to undertake a major in mathematics nominated this as a factor (see Figure 5.11).

While having an elective subject as part of a course, which was given as a reason by 22% of these students, may not seem to make sense, the reality is that some students were required to select a subject from a list of elective subjects offered by the faculty. Another reason for enrolling in elective mathematics is a lack of sufficient credit in mathematics to fulfil current course requirements.

The following response was given by a student who selected mathematics as an elective subject to fulfil his course requirements:
I would rather pick subjects that are electives for my course that involve mathematics since it is my strength (S104, Q15).

Another student had to take a mathematics subjects from a range of elective subjects for other majors:

From the array of electives available to teaching students doing physics, there are only two non-math department subjects to choose from, one of which is instrumentation. As such I will be choosing 2 math electives over my course, on top of the math electives from the math side of my degree (S142, Q15).

Sometimes an elective mathematics subject is recommended by the university and becomes part of a course (for example S196, Q 15) or it is part of their major course (S288, Q15 who is studying statistics for psychology).

The factor Did well in maths at school did not appear to be considered very important by students in selecting further elective mathematics as only 7% of students nominated this and, of these students, over half coupled this with Enjoyment.

The following comment comes from someone who regretted not taking higher mathematics at school:

Mathematics is fascinating to me and I’m really disappointed that I didn’t do higher level mathematics in school, which has limited what I can do now at uni. I’m one for logic and patterns and so, naturally, I really enjoy mathematics (err, depending on the subject I suppose.) (S268, Q15).

Another student discussed his learning style preference:

Mathematics is a skill and not a memory test. Once it makes sense, it’s easy to do those exams rather than needing to memorise a lot of information (S298, Q15).

In the beginning of her second semester the following student planned to change her program because of a strong interest in mathematics:

Planning on switching my double degree to BEng(Chem)/BSci (Chem+Math), as I have a strong interest in mathematics, more so applied mathematics, and seek to challenge myself and gain a better understanding of said math (S304, Q15).

An example of the usefulness of mathematics for a future career can be seen in the following student’s assertion of the necessity of mathematics in engineering:
Engineers must be proficient in the field of mathematics, therefore obtaining a minor or major will probably help me in future prospects (S139, Q15).

Enjoyment from mathematics and its benefits, in addition to its usefulness for employment are illustrated by the following:

I enjoy mathematics, and learning the subject has given me problem solving and logical thinking skills, so I hope further study in mathematics will continue to improve these areas and make me more employable (S370, Q15).

The following statement is an example of selecting more elective mathematics in order to master mathematics in other areas:

I’d like to try out Financial Mathematics as I believe it would help my studies in Commerce (in particular Finance) (S237, Q15).

For another student the reason for learning more of mathematics was that it is useful knowledge both in terms of education and industry:

I enjoy mathematics and I want to keep working in it. Mathematics underpins many areas of education and industry; I want to have a solid foundation in it (S123, Q15).

In summary, for students planning to take further elective mathematics subjects, by far the main reason for their choice was *Enjoyment*. They selected more mathematics because it was interesting; understandable instead of needing to be memorised; it increases employability; it helps in logical thinking and problem solving skills; and, ultimately, because large areas of these students’ study relate to mathematics.

### 5.2.6 Additional comments on the choice of mathematics at university

The other question that highlighted the different factors influencing a student’s decision to enrol in mathematics subjects was Question 41: *Please use the space below to add any comments you wish on the factors you think have influenced you in your choice of mathematics subjects or units at university*. The reason behind this question was to give students a chance to mention factors that they may have originally forgotten, ones that were not listed in the multiple choice questions, or that occurred to them while completing the survey.
Almost a quarter of the students offered responses to this question. Responses were classified as shown in Figure 5.15.

<table>
<thead>
<tr>
<th>Category</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part of course</td>
<td>25%</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>28%</td>
</tr>
<tr>
<td>High school experience</td>
<td>20%</td>
</tr>
<tr>
<td>Use in later career</td>
<td>9%</td>
</tr>
<tr>
<td>Mastery in subject</td>
<td>5%</td>
</tr>
<tr>
<td>Other</td>
<td>21%</td>
</tr>
</tbody>
</table>

*Figure 5.15. Percentage of students’ additional comments relating to different factors influencing their choice of mathematics, by category (N=75).*

This open response question showed that the two factors that had the highest frequency were *Part of course* and *Enjoyment*, with a considerable gap between these two and the other factors. This question was given without any guidance, similar to Question 1. It is interesting to note the similarity in the results between Question 1 (see Figure 5.5) and this question, given that in Question 12 (which was not open) the respondents indicated that *Part of course* was the main reason for enrolling in a mathematics subject.

An example of a student response, which was classified as *Enjoyment*, was:

Mathematics is beautiful, useful, and not changing much over time, relatively (S224, Q41).

The importance of continuing success with mathematics from school to university and developing an interest in the subject is seen in the response below, which was classified as *High school experience*:

I studied in Singapore till grade 8 (called sec 2 there) and since the standard is very high there I have had a very strong foundation in my Mathematics and science. This really helped me in doing well in mathematics here in Australia and hence, it improved my interest in mathematics further. This resulted in a positive feedback and made me do better in mathematics and so on (S188, Q41).
Some students however re-iterated that their only reason for doing mathematics was in order to fulfil course requirements:

I believed at the end of the HSC I would not undertake mathematics again. I did so in university because I was required to. I believe I can do well at mathematics when I am required to, but I do not enjoy it and as such tend to avoid it (S238, Q41).

While the question was open to any further comments, there were only a few statements that could only be classified as Other. For example:

I’ve basically grown fonder of mathematics ever since I started studying it at a university level. I believe it's more interesting now than it was in high school (S139, Q41).

The provision of a scholarship to study mathematics attracted another student:

The full scholarship that comes with the program I am currently enrolled in was tempting and made it easy to decide to study a bachelor of mathematics. If not, I may have considered some other degrees more seriously (S126, Q41).

A female student found mathematics challenging but suited to her abilities and her enjoyment was linked to situational interest:

I have Asperger’s syndrome, and I am female. I find mathematics to be a challenge. Things like makeup and being a secretary are not interesting to me. I enjoy mathematics because it's technical and it works well in my head (S319, Q41).

One student placed a very high value on studying mathematics:

I consider it to be an extremely beautiful and somewhat noble study and I would not feel right doing anything else (S4, Q41).

Obtaining different results from open response questions (Questions 1 and 41) and questions providing a list of possible responses (Question 12) asking about factors influencing students’ decision to choose mathematics at university suggests that the presentation of a question can influence the respondent’s willingness in giving an honest answer or amount of effort that they must put in (Holbrook et al., 2003). The inclusion of questions that allow them to use their own words results in unanticipated answers and better reflects respondents’ views (Thayer-Hart, Dykema, Elver, Schaeffer & Stevenson, 2010).
This section focused on the results from survey Questions 1, 12, 13, 15 and 41, which probed the various factors influencing students’ choice in enrolling in mathematics subjects at university. This included both multiple choice (Questions 12 and 13) and open response questions (Questions 1, 15 and 41). Different groups of students exhibited different patterns relating to the factors they identified as influencing their choice of mathematics at university, with many of the results being statistically significant. The Eccles Expectancy Value Theory of Motivation (see, for example, Eccles, 2009b) was used as a framework to analyse student responses. The factor Enjoyment, which was the factor most often identified by students enrolled in the Bachelor of Mathematics, as well as those students planning to undertake a major in mathematics, was also the reason given most frequently by students for undertaking elective mathematics subjects. As shown by the open responses from students, Enjoyment was linked with some students attributing a high intrinsic value to the study of mathematics, while for others it contributed to attainment value. Other factors relating to attainment value, such as Peer influence and Parental interest, were mentioned by very few students. On the other hand, the factor Part of course was the factor most often identified by students enrolled in courses other than the Bachelor of Mathematics, as well as those students only taking compulsory mathematics. It was even identified as a factor for choosing elective subjects by almost a quarter of these students. Open responses from students suggested that Part of course was linked with utility because the motivation for enrolling in the subject was external to the intrinsic benefits of the subject itself. The factor Use in later career, which was identified by only a small proportion of students, of whom most were undertaking a major in mathematics, was also seen as being linked to utility. The factor Did well in maths at school, while selected as a factor by as many students as was Enjoyment in the multiple-choice Question 12, was not prominent in students’ responses to the other questions. As well as being linked with expectation of success, student responses indicated that positive self-assessments of mathematical ability are often linked with enjoyment of mathematics (intrinsic value) and can also feature as a component in attainment value, with individuals seeing themselves as mathematically able people. This latter view is also linked with the factors Learning more and Mastery in the subject.

5.3.1 Students’ willingness to take a mathematics subject if it was not compulsory
To understand students’ motivation for enrolling in a mathematics subject if it was not compulsory, Question 10 asked: *If you are enrolled in compulsory mathematics subjects or units as part of your course, would you have chosen to take these if they were not compulsory?* The response rate for this question was high (N=335). The reason that this number is higher than the total of students who said they were taking compulsory mathematics subjects is probably due to the fact that some universities insisted that students take a minimum number of elective subjects, which students sometimes interpreted as therefore being compulsory. The question gave students three options: taking all of the subjects, taking some of them, and taking none of them. The purpose of this question was to reveal student enthusiasm about studying mathematics.

The findings from this question showed that 39% of students would like to take all of the mathematics subjects, 36% would like to take some, and 25% would like to take none of the mathematics subjects if they were non-compulsory. This result indicates that three quarters of the surveyed students undertaking compulsory mathematics subjects would enrol in at least one of them regardless of whether or not the subject was compulsory. However, a quarter of the students would not enrol in a mathematics subject unless it was compulsory. While the number of students who would take all of the subjects is almost the same as the total number of students doing a major or minor in mathematics, when the number of students who said they would take none of them was counted in each group it was found that three mathematics major students, from a total of 81 (4%), three mathematics minor students, from a total of 37 (8%), 15 students undertaking elective mathematics, from a total of 90 (17%), and 61 doing compulsory mathematics, from a total of 126 (49%), would not take these subjects if they were not compulsory. While these results show that almost half of the students doing only compulsory mathematics would not take these subjects if they were not compulsory, little can be inferred from the results for the other groups of students: they may well dislike their compulsory mathematics subjects, but may still want to take their elective subjects.

### 5.3.2 Students’ attitude towards undertaking more mathematics in the future

Another question that examined students’ attitudes towards mathematics was Question 11, which asked: *If you found that your future studies involved more mathematics*
than you expected, how would you feel about this? This open response question provided students with the opportunity to convey their feelings about becoming more engaged in the subject. The answers were grouped into seven categories as shown in Figure 5.16.

![Bar chart showing percentage of students with different attitudes towards taking more mathematics in the future (N=352).]

Figure 5.16. Percentage of students with different attitudes towards taking more mathematics in the future (N=352).

While over 80% of the students were neutral, happy or very happy to take more mathematics than they had expected, a minority would be unhappy or very unhappy at the prospect.

Some examples of students’ negative responses are presented below to illustrate these feelings:

Not happy as I don’t apply feeling to mathematics. I would simply understand my degree should be easier for me to grasp (S115, Q11).

A little bit intimidated because Mathematics isn’t my strength. I am only doing it because it will help with my science studies (S303, Q11).

Some students did not feel confident about their strength in mathematics:

Quite disheartened, mathematics is definitely not my strong suit. I would choose a program, courses or alternative university with less mathematics focus (S 47, Q11).

Mathematics is a subject that can be learnt quite easily provided you put in the time, dedication and practice. I feel like this becomes a deterrent as it requires some level of actual intrigue or satisfaction from mathematics in order for that level of work to be put in. Personally I have the opinion that my time and hard work can be better spent on more interesting and engaging subjects so I would be unhappy to find out that my future studies involved more mathematics (S372, Q11).

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Here is a student whose main concern was the adequacy of instruction he might receive:

Not too worried, as I enjoy Mathematics. However, doesn't mean I enjoy the way it's taught so I'm more worried about which teachers will be teaching me in the future (S51, Q11).

Others thought that taking unplanned mathematics depended on the level of those subjects and their ability to do the subject. In the following example the student was concerned about their future career:

A bit worry whether I am able to achieve considerably high achievement in my studies or not, but I'll continue. Challenging means the course is worth putting effort into and promises great career opportunities in the future (S63, Q11).

Other examples included students’ concern about their results, the quality of teaching, losing their part time jobs, or having mixed feelings, as shown in the following examples.

I guess I would feel excited for the challenge it may present, but it would also make me feel less enthusiastic for my future studies as it would mean less hands-on activities (S87, Q11).

I would have regretted not doing more math subjects, but I think I shall be fairly well covered (S11, Q11).

However many would be happy to do more, for example:

I like it ... better than some chem and bio stuff, as sometime when I did my chem. and biology practice I never learnt the theory about it before, it’s just sucks, but it never happen in Math (S68, Q11).

Other students would have been very happy, as illustrated by the following two responses:

I would love it! I find maths very stimulating and interesting (S355, Q11).

I would feel ecstatic. Mathematics always proves to show me something new I hadn't considered about it before (S37, Q11).

### 5.3.3 Students’ involvement with mathematics in their future university studies and careers
Students’ plans to include mathematics in their future studies and careers were addressed by Question 14: *Are you planning to enrol in more compulsory mathematics, more elective mathematics, a minor or major in mathematics, do post-graduate studies in mathematics or have mathematics as part of your future job.* Students were given the opportunity to select *definitely not, probably not, probably, or definitely* for each of the statements. The purpose of this question was to investigate students’ willingness to include mathematics in their future university studies and careers. Figure 5.17 shows the results from this question.

![Figure 5.17. Percentage of students anticipating taking mathematics as compulsory, elective, minor, major, in post-graduate studies, or in their future job (N=358).](image)

Figure 5.17 shows that two thirds of students definitely anticipate taking further compulsory mathematics subjects in their university courses, while over half expect to probably, or definitely, to take further elective mathematics subjects. These figures compare with approximately a quarter of students who anticipate probably or definitely taking a minor or major in mathematics. While the number expecting to undertake post-graduate mathematics is smaller, almost 20% still anticipate probably, or definitely, doing so. With regard to their future jobs, almost half expect to definitely use mathematics, with the number growing to 80% if those who expect to probably use mathematics are included as well.

In summary, this section reported on students’ attitude towards university mathematics and their future involvement with the subject. The results showed that only a
quarter of students would take none of their compulsory mathematics subjects if they didn’t have to do so. Fewer than 20% of students would be unhappy or very unhappy if they had to take more mathematics in the future than they had anticipated. Approximately 80% of students anticipated definitely, or probably, taking more compulsory mathematics and expecting it to be part of their future job, while over a half expected to definitely, or probably, take more elective mathematics, with approximately a quarter anticipating definitely, or probably, taking a minor or major in mathematics.

5.4 People who encouraged or discouraged students

People who have encouraged or discouraged students from undertaking university mathematics are discussed in this section.

5.4.1 People who encouraged students

Questions 16 asked: Who were the main people who encouraged or inspired you to learn mathematics? (You may tick more than one box) where boxes included: parents, siblings, relatives, family friends, primary school teachers, secondary school teachers, private tutors, peers or friends, impressive individuals, work supervisors, other. Question 17 then asked: If you ticked more than one box in the previous question, who encouraged or inspired you most?

The purpose of these questions was to determine the sources of encouragement for students to undertake a mathematics study. Students’ answers to both questions were then grouped and are shown together in Figure 5.18.
Figure 5.18. Percentage of students selecting categories of people who had encouraged them to learn mathematics (N= 348).

As seen above, secondary school mathematics teachers were most frequently selected by students as having encouraged them to learn mathematics. They were also the people who were most frequently selected as having encouraged students most, especially in the last year of school. The encouragement of mathematics teachers had a major impact on students’ performance, achievement and course choice as explained by these responses:

It was pretty equal, I am similar to my tutor in the way I find mathematics interesting, and my teacher constantly challenged me to do better (S105, Q17).

It had to be done. Those people just helped me the most. Teachers were the biggest help (S109, Q17).

Some survey participants mentioned the impact of other teachers:

Probably my high school physics teacher. He inspired me to follow physics, which means following mathematics (S328, Q17).

My primary school teacher, because he was the one who first made me realize how interesting mathematics could be (S18, Q17).

Parents were the next most frequently selected group, as illustrated by the following response:
Parents, my dad studied maths at university, so helped me/encouraged my maths from a young age. S263, Q17).

Among those responses characterised as *Other* were responses nominating a daughter, spouse, girlfriend, and school advisor, as these were not included in the list of people who had encouraged students. Also included in this category were approximately 7% of students who stated that they were encouraged by themselves, as exemplified by the following responses:

No one did [encourage me] I just have natural talent in the field (S5, Q16),

I just have an ingrained interest in maths (S34, Q16),

Myself, because I have always been good at math I prefer learning it over most other subjects (S106, Q16).

No real inspiration/encouragement from many, mainly from my own wider reading and seeing that the foundation of many sciences lays in mathematics and realising how important it is (S301, Q16).

I was not “inspired” by anyone. I know very few people, who inspire or truly love doing Maths as a pastime (S47, Q16).

Perhaps surprisingly, 12% of students selected *Impressive individuals*, naming well-known people and scientists, such as the following:

Newton, Gauss, Einstein, Hawking, Susskind, Feynman (S227, Q16).

Furthermore, one students attributes his interest in the subject to a radio interview:

Mathematical paradoxes are a great way to get people interested in maths, or at least, a great way to get me interested in it [...]. Also hearing a radio interview on P vs NP was really inspiring (S38, Q16).

The category *Other* also included students who learned mathematics for reasons other than personal interest or enjoyment, for example:

Sibling-rivalry developed where I wanted to prove that I was smarter as well as older (S66, Q17).
The effect of encouragement on learning mathematics will be discussed in the next chapter as students, who were interviewed, explained how encouraging people had an impact on their educational pathways.

5.4.2 People who discouraged students

Question 18 inquired: *Were there any people who discouraged you from learning mathematics? Please specify if the answer is yes.* The purpose of this question was to investigate any impediments students faced while approaching their mathematical learning pathways.

This question uncovered the effect of cost value on students’ pathways in learning mathematics. Cost value relates to the cost of carrying out a task in terms of resources such as money, time and other negative outcomes (Wigfield et al., 2004).

Almost a quarter of students who answered Question 18 (81 of 336) thought there was someone whose attitude toward mathematics was discouraging (see Figure 5.19). The discouragement they received might cost them in terms of money, time and other negative outcomes.

![Figure 5.19. Percentage of students nominating categories of people who had discouraged them from learning mathematics (N=84).](image)

Figures 5.19 shows that while secondary school teachers were most often named as encouraging students in Question 16, teachers were also most often named as most discouraging to them. In some cases, discouragement which affected students’ attitudes toward learning mathematics started at primary school. Being discouraged by teachers
resulted in a loss of enthusiasm and can create serious problems in terms of students’
attitudes and progress in the subject.

Primary school teacher said I was really bad at it and would never be able to do it
and fail at life ... well I got a B+ in Mathematics B and an OP6 ... so there you go (S24,
Q18).

Probably my Secondary school mathematics teacher [discouraged me]. He is the only
teacher I have ever seen to drag the top classes’ grades down just by being totally
useless so I had to teach myself the entire HSC course in my study break before
exams (S314, Q17).

My high school mathematics teacher was an abusive ... who made me hate the
subject by association (S379, Q18).

The attitudes of peers and friends affected almost a third of the students who
identified people who had discouraged them. Advisers, parents, and “everyone”
discouraged some students, while others were discouraged for other reasons, such as not
liking the heavy load of mathematics assignments.

Some said mathematics is a course that has heavy workloads and the career options
are not many. Moreover, most of those don’t provide high income (S63, Q18).

However, disappointment with university interactions could also deter students from
getting more involved with the subject:

I think I have outlined everything that has influenced my decision to CHOOSE
mathematics, but currently the university course I am enrolled in, is deterring me
from Mathematics (S105, Q41).

Interestingly, students whose responses were classified under *Everyone* tended not
to be affected by the discouragement, as can be seen in the following response:

People generally laugh when I tell them I’m studying a maths degree because they
can't understand why I like it and they just don't get how cool it is (S335, Q41).

Both type of students – those who liked mathematics and those who didn’t – had
been discouraged at some stage, influencing their attitudes towards the subject and
possibly their choice of university course.
In summary, teachers were most often selected as having encouraged learning of mathematics, but also were selected as being the most discouraging. Clearly teachers are highly influential in students’ choices to study mathematics. Parents were the next most often mentioned as encouraging the learning of mathematics, followed by siblings, friends, themselves, spouse, school advisor, and daughter. Peers and friends, advisers, parents, heavy workload of assignments, and “everyone” were mentioned as discouraging by some students. Significantly, early school experiences were important in forming attitudes to mathematics.

5.5 Students’ mathematics backgrounds

Students’ attitudes toward school mathematics, as well as the level and amount of mathematics that they had completed at school, were examined to review their mathematics background before commencing their university courses.

5.5.1 Students’ attitudes towards school mathematics

Question 19 examined students’ attitudes toward school mathematics. The question contained six multiple choice sub-questions:

I have always liked maths;
I liked maths when I had a good teacher;
I liked maths more in primary school than in secondary school;
I liked maths more in secondary than primary;
I liked maths more during the first few years of secondary school; and
I liked maths more during the later years of secondary school.

For these sub-questions, responses were given in a 4-point Likert-type scale comprised of: Strongly disagree, Disagree, Agree and Strongly agree. The purpose of this question was to explore students’ attitudes toward mathematics at various stages of their schooling.
Figure 5.20. Students’ attitudes toward mathematics at different levels of school (N=355).

More than three quarters of these students, who were undertaking first year university mathematics, agreed, or strongly agreed, that they had always liked mathematics, with a similar percentage liking it more in the later years of secondary school. However, the importance of good teachers is shown by the high percentage of students stating that they liked mathematics if they had good teachers, with 97% of students agreeing, or strongly agreeing, with this statement. This means students may not have problems with the subject, but rather indicates the important influence of teachers on attitudes towards mathematics.

Students were given an opportunity in the open response Question 20 to contribute any additional thoughts that they had related to school mathematics. This question asked students to: Please use the space below to add anything else you want to say regarding your attitude toward mathematics at school. Figure 5.21 shows the results of the analysis of the responses to this question.
Figure 5.21. Students’ additional comments regarding their attitude towards school mathematics (N=106).

The comments students most frequently wanted to add, regarding their attitude towards school mathematics, related to the importance of quality teaching. This was perhaps not surprising as there was no direct question in the survey about the student-teacher relationship. Students with positive and negative experiences asserted the importance of teaching methods and the impact of teacher interactions. The following examples express students’ feelings about both “good” and “bad” experiences:

I hated my year 9 maths class as my teacher was very difficult to understand and did not explain things properly. My senior maths teacher was great she went that extra step to show us how it works and made it interesting not just textbook stuff (S83, Q20).

It was extremely helpful to have a teacher that was able to make you feel comfortable in class to ask questions and also to be helpful (S3, Q20).

The second most frequent category of comments related to students’ enjoyment of the subject, with this sentiment expressed in a variety of ways. Enjoyment was deemed to be of great importance, as students had the option of discussing their enjoyment of mathematics several times throughout the survey, yet they still felt the need to comment on it further when given this opportunity. Several students who said they had always enjoyed mathematics spoke about enjoying the challenge it offered. For example:
I like to take challenges. I enjoy the feeling of solving challenging Maths questions after a lot of thinking and trying (S75, Q20).

Five students found the primary and junior secondary school syllabus boring, slow and repetitive, or irrelevant to the application of mathematics, and may have preferred more challenging senior secondary mathematics. For example:

As I have progressed through the years doing mathematics, it has occurred to me that what I did during primary school was arithmetic rather than math and I enjoyed 'math' more and more as it became more formal (S4, Q20).

Mathematics is all about progressive learning, so the information I learned in the later years of secondary schooling was far more interesting and complex to me. That seems to be why I enjoyed it more and more as time went on (S37, Q20).

I wish calculus had been more prominent, as calculus is where all the individually boring and tedious things we learn all come together into something useful and elegant (S75, Q20).

Mathematics B was very boring – only focused on a few topics and was taught at a ridiculously slow pace. Mathematics C was much more interesting, and varied (S21, Q20).

Needs to be more options for those who can handle more difficult branches of mathematics (S172, Q20).

When the two categories of *Always enjoyed maths* and *Enjoyed senior years more* are combined, responses in these two categories combined made up almost 40% of the comments.

There was a wide range of comments relating to the difficulty level. Some students who found the subject difficult and anticipated having to put more work in to keep up with their studies, whilst others found school mathematics easier than university mathematics:

I would feel slightly de-motivated since my current mathematics subjects are fairly hard. To know that there is more mathematics involved in the future would mean I would have to work extra hard to keep up (S228, Q20).

Mathematics was too easy at high school level. High school students are capable of much higher levels of mathematics if the teachers didn’t try to make it seem so hard for the students that are struggling (S5, Q20).
I've basically grown fonder of mathematics ever since I started studying it at a university level. I believe it's more interesting now than it was in high school (S139, Q20).

5.5.2 Students’ senior secondary school mathematics experiences

In addition to the survey examining students’ attitudes toward mathematics at primary and secondary school, Questions 21 and 22 inquired into the level of mathematics students had studied in their last two years of secondary school. These questions asked *Which Year 11 (Year 12) mathematics subjects did you take*, respectively. For each question, students were given the choice of selecting one or more of the following: *Highest level*, *Medium level*, *Basic level* or *No mathematics*. These questions aimed to understand more about students’ backgrounds in mathematics.

![Figure 5.22. Levels of mathematics taken by students in Years 11 and 12 (N=350).](image)

As can be seen in Figure 5.22, over 60% of survey participants claimed to have done the highest level of mathematics during both Years 11 and 12, with a similar percentage having taken medium level mathematics, and only 1% having taken no mathematics subject in Year 12.

Survey Question 23 collected more information about students’ Year 12 mathematics results asking: *If you did mathematics subjects in Year 12, which of the following best describes your results?* Students were given the choice of selecting one or more of Higher distinction, Distinction, Credit, Pass, or Fail for each of Highest level, Medium level, and Basic level. This question aimed to explore participants’ Year 12 mathematics grades.
Figure 5.23. Students’ Year 12 mathematics grades (N=237).

As can be seen in Figure 5.23, approximately 80% of students achieved a grade of Distinction or High distinction in Year 12 mathematics, with almost two thirds of students doing Basic level mathematics achieving a High distinction. Only 1 student failed in Year 12 mathematics.

Question 24 asked: *Do you think the grades you received for your mathematics subjects accurately reflect your achievement in mathematics?* The aim of this question was to examine students’ perceptions of whether the grades they were awarded reflected their achievement in their Year 12 mathematics subjects.

Responses showed that a high percentage of students (79%) agreed that their grade reflected their achievement, with only 21% disagreeing. However, as one student pointed out “achievement seems a strange way to put it, generally course grades in objective subjects reflect achievement” (S344, Q24) and most students who responded No to this question focussed on what they believed to be their potential at mathematics, rather than their Year 12 achievement. Reasons given by students for discrepancies are shown in Figure 5.24
A wide range of reasons were given by students for their grades not reflecting what they believed to be the extent of their knowledge, leading to 21% of the responses being categorised as Other.

The most common single reason that students believed resulted in poor grades was a lack of effort on their part (28%). This sometimes related to their low expectation of success (Eccles, 2009a):

I didn't put as much effort into my maths subject as I was pretty confident I would do better in other subjects, hence put in less time and effort in my maths subject (S266, Q24).

I didn't apply myself as much in high school than I have at a tertiary level. I am achieving much higher grades now that I know the mathematics I am studying is more relevant to my field of study (S139, Q24).

I was studying 7 subjects in Year 12 and was stretched things. I don't think I performed my best in any of my subjects (S27, Q24).

I didn't put in as much effort as I would have liked into my highest level of mathematics because of time constraints (S101, Q24).

Sometimes it related to students not attributing a high intrinsic value to their mathematics subjects, as indicated below:

Because in year 12 I did not really study hard for maths, my focus was more with English which was on a C in year 11, then went up to B+, and physics too which I was
second in class and engineering technology which I was the top student of the class (S131, Q24).

Other students however believed their grades were not a reflection of the effort they put in, as shown by the following response:

I put a lot of effort in with poor results (S32, Q24).

Only 10% of students gave reasons related to personal problems or illness as having affected their ability to study and learn. For example:

Had a bad few years in late high school with family problems that affected my ability to study and learn efficiently (S124, Q24).

However, 17% of students gave reasons related to the actual examinations – for example examination anxiety or making simple errors on the examination. For example:

I think my results reflected how I performed in the final exams. However, reflecting now on years 11 and 12 I think there was way too much pressure to perform well in exams. There is so much more to life after final years of high school and even if you don’t perform that well you can always find a way to do what you want to do (S179, Q24).

I get stressed extremely easily and the final exam (which is often worth the most) is the one I consistently do substantially worse in (S243, Q24).

Perhaps surprisingly, 7% of students reported that their results were better than they expected. Some of these students had low expectations of success as indicated below:

Sometimes I wonder whether or not I was good enough to receive such high marks (S380, Q24).

... in highest maths SCALING :D made me look good when actually I was fairly incompetent ... (S293, Q24).

A further 7% indicated that their grades were irrelevant to their belief in their own ability or their enjoyment of mathematics, again relating to Eccles’ (2009) notion of intrinsic value and attainment value, as shown by the following responses:
I think the HSC result I got for mathematics was lower than my understanding of mathematics. That mark however, is irrelevant, it has not stopped me enrolling in a heavily mathematical course, or stopped me enjoying mathematics (S69, Q24).

Even though I did badly in mathematics during high school I enjoy it and believe I have an aptitude for it (S378, Q24).

A further 6% nominated reasons relating to the system – including methods used to standardise marks based on other students’ performance, as well as the appropriateness of the topics and methods of assessment. For example:

I believe there were some discrepancies in the marking and so forth. I believe that I did worse than my potential that year (S166, Q24).

Part of my result in Year 12 was affected because the questions in the exams were made to be very difficult so that when random folder of students' works are sent in to be compared with students from other school, it will affect the average OP score of the entire school (S63, Q24).

My strongest point is problem solving, which is not tested to such a great extent (S285, Q24).

Very few students nominated unhelpful teachers, or responded that they were unsure of why their results did not meet their expectations. One student, who believed he did not receive adequate help from teachers explained:

As there were disruptions to mathematics teachers at my school (we didn't have one for several months), I feel I could have achieved a much better result. This year, I undertook a mathematics bridging course that was equivalent to mathematical methods and achieved (99%), proving my suspicion. At school, teachers spent more time disciplining students than teaching, which was frustrating (S377, Q24).

In summary, over three quarters of students stated that they had always liked mathematics, with a similar percentage liking it more in the later years of secondary school. However, the importance of quality teaching was evident in student responses to several questions, with 97% of students agreeing that they liked mathematics if they had good teachers. Many students found the primary and junior secondary school syllabus boring, slow and repetitive, or irrelevant to the application of mathematics, and preferred senior secondary mathematics. Over 60% of survey participants claimed to have done both highest
and medium level mathematics during both Years 11 and 12, with approximately 80% of these students achieving a Distinction or High distinction grade in Year 12 mathematics, and almost two thirds of students doing Basic level mathematics achieving a High distinction. So the respondents to this survey achieved a high degree of success in senior secondary school mathematics. Almost 80% of students believed their grade reflected their achievement, with the most common single reason given by students for poor grades being a lack of effort on their part.

5.6 Other factors influencing students’ choice of mathematics

In order to investigate possible relationships between students’ family backgrounds and their decisions to study mathematics, a range of demographic and other data was collected. Results from the analysis of students’ responses to these questions are discussed below.

5.6.1 Country of birth

Questions 25, 27, and 28 asked students to nominate their own, their mother’s and their father’s country of birth, respectively, while Question 26 asked students to nominate the country in which they completed Year 12. The aim of collecting these data was to have some information about the possible relationship between students’ geographical backgrounds and their choice of mathematics. The information generated was grouped into the following main clusters: Australia and Oceania; Africa and the Middle-East; America and Europe; and Asia.

Data from Question 26 show that 321 of the 325 students who answered this question (99%) completed Year 12 in Australia.
Figure 5.25. Birth countries of students and their parents

Figure 5.25 shows the data from Questions 25, 27, and 28. As can be seen in Figure 5.25, over three quarters of the students surveyed were born in Australia and Oceania, while approximately half of the remainder were born in Asia, with just 5% of students born in each of Africa and the Middle-East, and America and Europe. Rather fewer students’ parents were born in Australia or Oceania, with almost a quarter of both mothers and fathers born in Asia. The data also showed that 164 students had parents who were both Australian, 57 students had one Australian parent, and 130 students had both parents not born in Australia.

The focus of Question 25 was to find out if there is any relationship between students’ place of birth and the factors they nominated as influential in their choice of mathematics.

Figure 5.26 shows that most students born in African and Middle-Eastern countries nominated Enjoyment most often, while the other three groups of students nominated Part of course most often. Students born in America or Europe were the most likely to nominate High school experience, while those born in Asian countries were the least likely to nominate Use in later career.
Figure 5.26. Percentage of students nominating different factors that influenced their choice of mathematics, by country of birth (N=348).

Due to the smaller number of responses in some of the categories, it was not possible to carry out a Pearson chi-square test as more than 20% of the expected counts were less than 5. Results from conducting z-tests (and t-tests for cases when the sample sizes were less than 30) showed no statistically significant difference (at the p<0.05 level) between the proportion of students from different countries of birth selecting each of the factors.

The relationship between students’ place of birth and the amount of mathematics they were undertaking were also examined. Responses obtained for Question 14 regarding students’ mathematics sequences were examined taking into account students’ country of birth. The results of this analysis are shown in Figure 5.27.
Figure 5.27. Percentage of students from each country taking different mathematics sequences (N= 355).

Figure 5.27 shows that approximately a quarter of students from Asia, and Australian and Oceania, were planning to undertake a major in mathematics, a higher proportion than for those from America and Europe, and Africa and the Middle-East. For all groups, apart from those born in Asia, the greatest proportion of students were only undertaking compulsory mathematics. However, when a chi-square test was used on the data shown in Figure 5.27, it resulted in a p-value greater than 0.05 indicating that there was no statistically significant relationship between students’ country of birth and their planned mathematics sequences. Further, when pair-wise z-tests (and t-tests where appropriate) were carried out on proportions of students from different countries of birth and their mathematics sequences, no statistically significant differences were found.

5.6.2 Cultural identity

After identifying the birthplace of students and their parents, Question 29 asked: Do you identify yourself with a particular cultural group? If yes, please identify. The purpose of this question was to identify students’ own beliefs about their cultures. Among the 353 students who answered this question, 281 students did not identify themselves with a particular cultural group while 72 students did. Among these, 64 students nominated their cultural group, and 8 students did not. Figure 5.28 shows the cultural groups identified by the 64 students who nominated these.
This classification was made difficult by the fact that a number of students identified themselves as belonging to more than one culture – e.g. “Tamil-Australian”, “Australian, then Lebanese”, and “Aboriginal and Italian”.

The relationship between culture and choice of university course was addressed in Question 30: *If you identify with a particular cultural group, do you think this has affected your choice of university course? If yes please explain how.* Although 72 students identified with a cultural group, just 22 students (6% of all participants) acknowledged a cultural influence on their choice of university course. Only 18 of these students indicated the nature of the direct influence of family culture on their university course selection.

Among these, a number thought their culture strongly influenced their studies, in that coming from a particular background meant having to do a particular courses to make them ready for a particular job. The influence of culture on university choices can be seen in these examples:

In our culture our parents push/ force us to either do MBBS, Dental Science, Engineering, Law and other such courses of "high reputation". Hence, this kind limited my spectrum of course selection (S188, Q30).

My family has always encouraged me to go towards mathematical and scientific subjects as they are not subjective. There are definite answers, and thus if you are good at it, you can be (almost) guaranteed success (S52, Q30).
Families with Vietnamese cultural background tend to tell their children to study courses that are regarded as honoured and supposedly provide high income such as medicine, pharmacy, dentistry or law. We also often avoid courses that involve music, dram[a] or art (S63, Q30).

Students admitting that culture affected their choice of course were mostly from families more concerned about the possibility of an engineering job at the completion of studies as can be seen in the following response:

My parents always wanted me to do this course. I wasn't really given much option to choose from about the choice of university course (S200, Q30).

Another student emphasised how important culture can be:

I identify as Sinhalese Sri Lankan. This is important to me because I don't believe, nor do I have the luxury of cultural or colour blindness. So I embrace who I am (S93, Q30).

The impact of cultural background on students’ course choice has been discussed by many researchers – for example, Ma, Hobart et al. (2006), Salami (2007), Hannula et al. (2007), and Ma (2009). In this survey, just 6% of participants suggested that some decisions, related to their choice of course, were related to their cultural identity.

5.6.3 Parents’ education

Questions 31 and 32 investigated the highest level of parental education: My mother’s (father’s in Question 32) highest level of education was: Primary school, Secondary school, TAFE or Diploma course or equivalent, Bachelors degree, Post-graduate degree.

Figure 5.29. Parents’ highest level of education (Mother: N=350; Father: N=349).
As can be seen in Figure 5.29, the survey results show that 59% of students’ fathers and 50% of mothers had a university degree. Overall, 251 students had at least one parent with a Bachelors or Post-graduate degree, with 128 students having both parents with a university degree. A total of 199 students had at least one parent with Secondary school or a TAFE certificate, with 82 students having both parents with Secondary school or a TAFE certificate. A total of 25 students had at least one parent with just Primary education, with just 4 students having both parents with just Primary education.

The relationship between parental education and a student’s choice of university course was investigated through Question 33: Do you think your parents’ education has affected your choice of university course? If yes, please explain how. Of the 352 students who answered this Question, 96 agreed that it did affect their choice of university course.

![Figure 5.30. Influence of parents’ education on students’ choice of course (N=99).](image)

The results show that 106 students (30% of those who answered this question) acknowledged the effect of their parents’ education on their choice of course. Of the 99 students who explained how their parent’s education had influenced their choice, the most frequent reason given was their family’s focus on education (43%). For example, one student who was studying Engineering had one parent with a Postgraduate degree and the other with a Bachelors degree wrote:

> Both my parents have graduated university and I could never imagine myself doing anything different. It would be like announcing to the world that I'm dumb (S27, Q33).

Another Engineering student with one parent who had a Bachelors degree and the other a Secondary education claimed:
There has always been and expectation of attending University however the choice of engineering is my own and not affected by my parents (S179, Q33).

Other students were motivated by the desire to have a better education than their parents (14%). They were often encouraged by their parents to work to the best of their ability, as one student taking Nano-science and whose parents had a diploma explained:

It has motivated me to make the most of my opportunities, because they did not have them (S390, Q33).

Another student valued the support his parents provided for his university expenses:

Although my parents just finish high school but they always ask me to study hard and they will try their best to pay my school fees until I finish my university (S315, Q33).

Approximately 15% of students were inspired by their parents’ field of study or work, as one science degree student, whose father was a mathematics teacher and whose mother had a Bachelors degree, explained:

My father is very mathematically minded and a good teacher. I owe a lot of my skill in mathematics to him (S360, Q33).

Some students also mentioned their parents’ desire for them to attend a particular university. One double degree Science and Engineering student explained:

My parents refused to let me attend anywhere except [name of the university] (where they went). Because they both attended university they believed that I deserved the opportunity to do the same. They completed science-related degrees and so encouraged me to do the same (S85, Q33).

Another student, who was doing a Bachelor of Science and whose parents both had Bachelors degrees, explained:

My mum completed her Bachelor in dentistry, and my dad completed his Bachelor in computing both of which are heavily reliant on both science and maths. I don’t think their education directly affects my choice, but it probably PASSIVELY affected my decision (S265, Q33).

However, other students (18%) attributed the effect of their parents’ education to their focus on mathematics and science. For example, one Bachelor of Science student
wrote of the effect of being exposed to science by parents who both have Postgraduate degrees in science:

They are both successful scientists and I have constantly been exposed to it through my life (S152, Q33).

A small number of students (3%) believed their parents were concerned about the income that could accrue from a good education, as can be seen in the following example of a Business student with parents who had Bachelors and Postgraduate degrees:

My parents studied arts courses which earned them lower-middle class jobs that they hated. My brother and I were pushed into maths and science; parents figured there were better returns in these fields, though they have no knowledge of them (S149, Q33).

Among the 9% of students whose responses were classified as Other, a small number of students (3%) reported that their parents’ education had negatively affected their choice of course. For example, a student of Medical Science whose parents have a Bachelors degree and a Diploma said:

I know that I don’t want to do what they did – law (S300, Q33).

In order to further examine the relationship between parents’ level of education and students’ choice of university course, the percentage of students who reported that this influenced them was calculated for both parents for each of the five levels of education. The results are shown in Figure 5.31.
Figure 5.31. Percentage of students reporting parents’ education as influencing choice of course (Mother: N=350; Father: N=349).

The highest proportion of students reporting their mothers’ level of education as influencing their choice of course was for those students whose mothers had only completed Primary school, while for fathers’ education the highest proportion occurred for those students whose fathers had Postgraduate degrees. In order to test the statistical significance of the apparent differences for different levels of education, z-tests were carried out.

The results from the z-tests showed a highly significant difference for the proportion of students whose mothers had only completed Secondary school reporting that their mothers’ level of education had influenced their choice of course when compared with those whose mothers had a Bachelor degree (p<0.001); a significant difference when compared with those whose mothers had only completed Primary school (p<0.01), and a significant difference when compared with those whose mothers had Postgraduate qualifications (p<0.05). No other statistically significant differences were found in terms of mothers’ levels of education.

The results from the z-tests also showed a highly significant difference for the proportion of students whose fathers had Postgraduate qualifications reporting that their fathers’ level of education had influenced their choice of course when compared with those whose fathers had only completed secondary school and also those who had a TAFE or Diploma qualification (p<0.001); and a significant difference when compared with those whose fathers a Bachelor degree (p<0.01), and a significant difference between those whose fathers had a Bachelor degree and those whose fathers had had only completed Secondary school (p<0.05). No other statistically significant differences were found in terms of fathers’ levels of education.

These results are consistent with those found by other researchers regarding the impact of parents’ levels of education on students’ willingness to undertake tertiary study (e.g. OECD, 2003; Lyon, 2004; Davis-Kean, 2005; Hannula et al., 2007; Ma, 2009; McPhan et al., 2008; Tytler et al., 2008; Panizzon & Westwell, 2009).

5.6.4 Parents’ occupation
Parental occupation was explored in Questions 34 and 35: How would you describe your mother’s father’s occupation? The aim of this question was to determine whether this factor influenced students’ choice of university course.

Parents’ occupations varied from a university Deputy Vice Chancellor to tradespersons and the unemployed. Merging occupations into major categories was required. Occupation lists were extracted from the Australian Bureau of Statistics (2012), with occupations then grouped into seven categories: Professional (including Managers); Health/Education; Service/Sales (including Armed forces and Clerical support); Self-employed (including Artists, as well as Agriculture, Forestry, and Fishery workers); Technicians (including Engineers, Crafts, Plant and Machinery workers); Unemployed (including Housewives, Unemployed, and Retired), and Other.

Some students did not understand the questions and tried to define their parents’ attitudes toward their jobs explaining them as: stressful, boring, tiring, underpaid, or good and rewarding. Parents of these students, together with deceased parents or parents who were described as having lost contact with their children, were categorised as Other. Figure 5.32 shows the percentage of mothers and fathers by occupational category.

![Graph showing parental occupations](image)

**Figure 5.32.** Parents’ occupations (Mother: N=332; Father: N=323).

After identifying parental occupations, students were asked in Question 36: Do you think your parents’ occupation has affected your choice of university course? If yes, please explain how. Out of the 350 students who answered this question, 75 claimed their parents’ occupation had affected their choice of university course (21%). Sixty-seven of these
students provided answers to explain how their parents’ occupation had affected their choice of university course – see Figure 5.33.

![Bar Chart](image)

**Figure 5.33.** Influence of parents’ occupation on students’ choice of course (N=67).

Just over half of the survey participants who explained how their parents’ occupations had affected their choice of university course considered the effect as positive, inspiring them to enrol in a course that would lead to a similar occupation as their parents, while almost a quarter disliked their parents’ occupations and chose to do something different.

The perceptions of how and why their parents’ careers had an impact on students’ choices varied. For example, one of a number of engineering students, whose fathers were also engineers, wrote:

I don't tend to dive into the unknown. My dad is an Engineer and from what I'd seen of his job, I thought I would enjoy it. I still think so (S27, Q36).

A Bachelor of Science student whose mother was a secondary school mathematics teacher and whose father was a manager claimed that his course choice was related to his parents’ mathematics related occupation:

My parents' occupations have showed me that mathematics can be used in many different fields (S113, Q36).

However, some like an Engineering student who found his parents’ “mathematics based jobs” very dry, were pursuing a different occupation from their parents:

I found I did not want to study computer sciences [parents job], despite their high mathematical content (S66, Q36).
Some parents’ occupations encouraged students to pursue higher education. For example, a Bachelor of Science student claimed his lecturer father sparked his interest in university culture:

I’ve experienced a bit of the university culture through my father, so that's sparked my interest (S 93, Q36).

The high income of a parent’s occupation was seen as a good reason for a Bachelor of Science student’s academic achievements:

High salary of father’s job encouraged me to study a tertiary degree (since, on average, tertiary education graduates earn more (S61, Q36).

Another Science student, whose parents’ occupations were child-care worker and factory worker, was motivated to work hard for a better job:

[Parent’s job] makes me want to work harder and get a better job in the future (S357, Q36).

The response of an Engineering student with a Library Assistant mother and a father who was a policeman was categorised as Other. He stated he wanted a higher level of education than his parents in order to get a better job:

I want better jobs (higher paying, more enjoyable, better advancement opportunities) so I decided to pursue tertiary education (S334, Q36).

In order to further examine the relationship between parents’ occupations and students’ choice of university course, the percentage of students who reported that this influenced them was calculated for both parents for each of the seven categories of occupations. The results are shown in Figure 5.34.
Figure 5.34. Percentage of students reporting parents’ occupations as influencing choice of course (Mother: N=332; Father: N=323).

The highest proportion of students reporting their mothers’ occupation as influencing their choice of course was for those students whose mothers were technicians, while for fathers’ occupation the highest proportion occurred for those students whose fathers were in education and health. In order to test the statistical significance of the differences for different levels of education, z-tests were carried out.

The results from the z-tests showed a significant difference for the proportion of students whose mothers were technicians reporting that their mothers’ occupation had influenced their choice of course when compared with those whose mothers were professionals ($p<0.05$) and also those whose mothers were employed in service and sales, and between those students whose mothers self-employed and those whose mothers were employed in service and sales ($p<0.05$). No other statistically significant differences were found in terms of either mothers’ or fathers’ occupations.

### 5.6.5 Financial status

Questions 37 asked students about their parents’ financial status: During your time at secondary school, which of the following would best describe your family’s financial situation: well off, comfortable, struggling? Question 39 asked: Which of the following best describes your current financial situation? Well off, comfortable, struggling? The purpose of these questions was to ascertain both parents’ and students’ financial status. The results are shown in Table 5.4.

Table 5.4
Family’s financial status during students’ schooling and students’ current financial status
The results show that students who described their current financial as Well off or Comfortable predominantly came from family’s whose financial situation was similar during their schooling, with approximately 80% of students describing their own or their family’s financial situations as either Well off or Comfortable. This result is consistent with previous research which has found that students doing mathematics usually come from well off families (Pedrosa et al., 2006; Moor & Creaph, 2013). However, by way of contrast over 60% of the students who described their financial situation as Struggling also described their family’s financial situation as Well off or Comfortable.

To find out about the relationship between parents’ financial status and students’ decisions when choosing their university courses, Question 38 asked: Do you think your family’s financial situation has affected your choice of university course? If yes please explain how. Question 40 also asked students: Do you think your financial situation has affected your choice of university course? If yes please explain how. The aim of these questions was to reveal the impact of financial status on doing mathematics at secondary school and university.

From 350 students who answered Question 38, 297 reported no effect and 53 gave a positive answer and explained why. From the 256 students who answered Question 40, 210 students did not report any effect of their family’s financial status on their choice of university course, but 46 students believed there had been some effects. Responses were classified into five categories. Figure 5.35 shows the result of this analysis.
Figure 5.35. Effect of families’ and students’ financial status on choice of university (Family: N=53; Student: N=46).

While discussing the effect of family financial status, Prioritizing financial stability was nominated by the largest proportion of students (26%). This was also nominated by the largest proportion of students when discussing the effect of their own financial status (30%). Other factors influencing students’ choice of university, and course, and students’ ability to pay for their courses, were also identified by between 15% and 24% of students.

The need to prioritize financial stability was evident in this response from a student from a struggling family:

I would consider the future careers of my university course so that I could help my family's financial situation in the future (S332, Q38).

Another student was worried about future income and perhaps selected a course in which she was less interested:

Were my parents “well off”, I may have chosen to pursue a program with less guarantee of high income but which I was more interested in, such as entrepreneurship, as I would have someone on which to fall back (S334, Q38).

Yet another student wrote:

I'm into philosophy and writing, but I'm half a million dollars in debt so studying “for fun” seems out of the question. Maths will earn me a higher starting salary than those other things (S381, Q40).
However, a student from a well off family just wanted to be richer than her parents and stated:

I want to be more “well off” compared to my parents. I also heard that mathematicians earn a nice wage (S385, Q38).

In terms of freedom of choice of university, one student who was financially comfortable wrote:

I am lucky enough to be part of a family with a comfortable financial situation and so I am able to attend a fine university and enrol in my course of choice (S106, Q38).

By way of contrast, another student wrote:

If I were rich I would’ve gone to Sydney or Melbourne (S46, Q40).

And a student from struggling family complained that:

I may have looked into a different course in a more expensive/private university (S133, Q38).

Being able to enrol in a course of choice was explained by a student from a well off family as follows:

I am not so focused on the course as a stepping stone to a career more as exploration of options because of the comfortable nature of family’s financial situation (S294, Q38).

Another student stated:

I was able to choose whatever I wanted because we are financially stable (S85, Q38).

Conversely another student related that his course choice was due to lack of financial help:

Lack of tutoring in high school etc. led me to do badly in high school and led me indirectly to my current course (S375, Q38).

Another student needed to think about their time and cost constraints:

I can’t fail too much subjects that’s why I study some courses with less compulsory subjects (S268, Q40).
Paying for a degree was possible for this student from a family with high earnings who studied at his favourite university:

Parents are paying up front; I don’t have to worry about it (S261, Q38).

However, paying for university studies was reported as a major problem for students from families that could not provide financial support:

I hope to get a good scholarship through my university as I am not able to get any form of financial support as my parents earn too much, which doesn't mean much with five children (S83, Q38).

If I had to work a lot of hours to be able to support myself at uni I may have been discouraged from engineering/commerce as I may have had to take the course part time which would have taken many years to complete as even full time it is 5.5 years (S26, Q40).

Some students also discussed having problems paying for textbooks or other study expenses:

Sometimes it's hard to buy books especially textbooks cause it costs so much and we need that money for more important purposes (S357, Q38).

Students’ responses categorised as Other gave examples such as the following:

Currently, I am struggling to pay to get to and from university; I may have to drop out to work (S313, Q40).

I would like to be able to earn money sooner so I will not contemplate transferring to engineering (which was an option that I had left for myself) because that would mean that I would have to study longer and therefore be employable later (S215, Q40).

It has driven me to be a high achiever in order to be better off in the future (S359, Q38).

The influence of low financial status on students’ choice of university course mostly involved the need for students to change their preference field or their desired university. Changing course of study sometimes resulted in changes to future career options.

This section revealed cost value emerging for financially disadvantaged students, especially at the time of university course choice. Some had to forego their first choice and select another because of not being able to pay university fees, or because they needed to
quit work or study for longer. Others needed to enrol at universities other than their planned place because of not being able to afford to move out of home or travel to another location. As Eccles (2009b) asserted, people have access to limited amounts of energy and time. Costs can occur in terms of loss of time and energy allocated for other activities that sometimes are more the focus for personal identities (Eccles, 2009b). This concern was expressed by students who had to change work and study plans.

In summary, *Enjoyment* was reported more often by students born in African and Middle-Eastern countries, while *Part of course* was reported more often by students born in other countries. More students born in America, Europe, Africa and Middle-East planned to major in mathematics than those in other groups. Just 6% of all respondents acknowledged the influence of culture – mostly family culture – on their choice of university course. When considering parents’ education, almost two thirds of students had at least one parent with a university degree, while almost one third had both parents with a university degree, and only four respondents (1%) reported that both parents had just Primary education. About 30% of those who answered this question referred to the effect of their parents’ education on their choice of course. The highest proportions of students who reported the effect of parents’ occupation on their choice of course were those who had mothers with employment in the technician category and fathers working in education and health.

A comfortable financial position was reported by most survey respondents for both themselves and their families. The respondents suggested prioritising financial stability; ability to pay for course and not having to change their preferred course; and university or later career options as the most influential considerations regarding their choice of course.

**5.7 Summary of the survey findings**

This chapter reported on the findings from a survey conducted with university students enrolled in first-year mathematics subjects at six universities in three Australian states. Approximately three quarters of the students were enrolled in Science, Engineering, or a combined Science and Engineering degree. For most of these students the course they were enrolled in was their first choice. Approximately a third of the students were planning
to undertake either a Major or a Minor study in mathematics, while 40% of students were only intending to study compulsory mathematics.

Survey participants’ responses to the 41 open response and multiple-choice questions were analysed to determine factors that influenced students’ choice of mathematics at university. Analysis of quantitative data included statistical tests, while possible, while qualitative responses were analysed using the Eccles and Wigfield’s Expectancy Value Theory of Motivation (Eccles et al., 1998; Eccles & Wigfield, 1995, 2002; Eccles (2009a, Eccles 2009b; Wigfield & Eccles, 2000, 1992; Wigfield et al., 2004). A summary of these factors follows below.

Nine factors were nominated by students, with the analysis relating these to the Eccles framework. Intrinsic value was evident in the factor Enjoyment, while the factors Part of course, Prerequisite, Use in later career, and Mastery in subject were related to attainment or utility value, depending on the survey respondents’ long- or short-term goals. Maths experience and Did well at school were combined into the factor High school experience, which provided evidence of expectation of success. Impediments to pathways for learning mathematics, such as inadequate instruction or assistance, and discouragement expressed – particularly by teachers, both Primary and Secondary – and peers, were considered as cost value.

In response to questions examining survey respondents’ attitude towards mathematics only a quarter of them would not take their compulsory mathematics subjects if they were not required to do so. More than three quarters of survey respondents always liked mathematics at school and three quarters also liked it more in the later years of Secondary school. However 97% of survey respondents indicated that they liked mathematics if they had good teachers. Five survey respondents also commented that they found the mathematics syllabus at Primary and junior Secondary school repetitive and irrelevant to the application of mathematics and preferred senior Secondary mathematics. Almost two thirds of survey respondents had done the highest level of mathematics in Year 12, with almost 80% of them achieving a grade of Distinction or High Distinction. About 20% of survey respondents believed their grade did not reflect their achievement, citing lack of effort as the most common reason.

Over three quarters of the survey respondents and approximately 60% of their parents were born in Australia or Oceania, while approximately half of the remainder, and a
quarter of all parents, were born in Asia. No statistically significant relationships were found
between students’ country of birth and factors they claimed had influenced their choice of
university course or their planned mathematics sequences.

Although almost 20% of students identified with a cultural group, only a third of
these (6% of all participants) acknowledged a cultural influence on their choice of university
course – mainly in terms of believing they had to take particular courses to make them
ready for a particular job.

Over half of all parents had a university degree. Almost a third of survey respondents
who answered the question about parents’ education agreed that it affected their choice of
course, with the most frequent reason given being their family’s focus on education.

Parents’ occupation was reported by approximately 20% of survey respondents to
have had an effect on their choice of university course, with over half of these students
considering the effect to be positive, inspiring them to enrol in a course that would lead to a
similar occupation as their parents, while almost a quarter disliked their parents’
occupations and chose to do something different.

More than 80% of survey respondents and their families were reported to be
financially comfortable or well off, with only 15% of students reporting any effect – positive
or negative – due to financial status.

The next chapter focuses on the second stage of data collection involving the
interviews.
CHAPTER 6    RESULTS FROM THE INTERVIEWS

This chapter reports interview data collected from 27 students. These students were selected from the 126 survey respondents (of 391) who volunteered to take part in the interviews. As mentioned in Chapter 3, the interviews were included in the research design because answering questions from a sympathetic listener is more rewarding for respondents than the task of filling in a form for an anonymous researcher (Phellas, Boch, & Seale, 2012). This enables entire events to be chronicled, which can be the most powerful representation of experience. As recommended by Harris and Brown (2010), interviews were used to obtain in-depth data in addition to the survey, to provide insight regarding selection of mathematics at university.

In this chapter, data collected by qualitative methods obtained from interviewing 27 students will be presented and analysed, with a particular emphasis on findings from 11 individual student case studies, representing different categories of interviewees.

6.1 Participants

Students participating in the interviews were chosen from the 126 survey respondents who indicated their willingness to be interviewed by agreeing to the last question of the survey. The high rate of positive responses to the final question on the survey provided the opportunity to select participants according to predetermined criteria for the second part of data collection, the individual interviews.

6.1.1 Selecting the interviewees

The first step for selecting interviewees was to review their survey responses. The planned strategy for selecting interviewees was based on a set of characteristics that was adopted from the literature review and survey results (see § 4.2.1 for details).

In brief, selection criteria were based on diversity of survey responses regarding student motivations, socio-economic backgrounds, cultural backgrounds, attitudes towards learning mathematics, preferences for mathematical study, the influence of peers, and other factors mentioned as influencing students’ choice of university course.
Students who appeared to be intrinsically motivated, as well as those who appeared to be extrinsically motivated were included, as were students from high and low socio-economic backgrounds. Anyone who mentioned identifying with a particular culture or family or who described parents as influential and had something interesting to say about these topics in the survey were included under cultural background. Students who were doing a mathematics major and indicated they like mathematics, together with those who were taking mathematics as a course requirement and indicated that they didn’t like mathematics were included under the group orientation towards mathematics learning. Any who mentioned peer-group influence and some students who studied mathematics as either their first or second choice were included in the choice of course category.

Within these categories, students were also chosen for a range of characteristics: providing firsthand accounts; showing enthusiasm or indication of experiencing a unique situation; belonging to diverse cultural, or socio-economic backgrounds; being of mature age with diverse work and life experiences; obtaining high results in mathematics at school; living in a remote area, as well as having taken different pathways into university; acknowledgment of unsuccessful experiences; and having dropped out at some stage.

Students with these characteristics were chosen because it was believed that they could better inform the research through data about their diverse experiences, knowledge, and opinions, attitudes and beliefs (Stacks, 2002). It was necessary that the data collected inform the researcher about students’ decisions to study higher mathematics, their perceptions of their school experiences and cultural backgrounds, how they valued doing mathematics at university, as well as clarifying pathways that were being undertaken in these journeys.

The answers of 78 students who seemed the most promising in relation to the criteria were short listed for closer attention and, after further reviewing their survey responses, 35 students were selected to be invited for individual interviews.

All 35 students were contacted by email and telephone. Twenty-eight students from three different states accepted the invitation to attend the designated interviews. Only one student was not able to attend, while the other 27 students completed the interview at the agreed time and place.
Figure 6.1. Interviewees’ categories by selection strategy (N=27)
Figure 6.1 shows the different categories used to select the 27 students who participated in the interviews. In this figure, students are grouped according to the different selection criteria. For example, the survey data of S391, S326, S142, S240, and S276 suggested they were primarily intrinsically motivated, but the survey data of S38 and S126 suggested they were primarily extrinsically motivated. In other examples, students S369, S294 and S264 were included in the high socio-economic and S47 in low socio-economic background category. While student S336 liked and was majoring in mathematics, S178 and S261 did not like mathematics but had to do it. Survey responses of students S384, S378, S250, and S135 suggested they were influenced by parents or culture, S391 was influenced by relatives, while S354, S145, and S245 reported that ethnicity and S379 and S377 reported that peer groups had impacted on their choice of course. Students S339 and S87 enrolled in mathematics as their first choice, while S350 and S280 were enrolled in their second choice. However, it is important to note that there are overlaps of categories in most dimensions, although just one selection criterion was considered for each student for the sake of simplicity.

6.1.2 Summary of interviewees’ survey responses

Information about interviewees’ backgrounds can be found in Table 6.1 below. Columns 1, 2, 3 and 4 present data about interviewees’ university, course and the type of mathematics sequences they were undertaking or planning to undertake (see § 5.1.4), summarising responses to Questions 2, 3, 7, 8, and 9 of the survey. Column 5 shows the reasons for selection of the interviewees, taking into account the whole set of answers, while columns 6 and 7 explain the reasons given by students on the survey for choosing their current mathematics subjects and courses. Data for these columns comes from responses to Questions 1, 12, 13, 15, and 41 of the survey. Column 8 indicates their attitudes toward mathematics, based on responses to Questions 10, 11, 14, and 19 to 24 of the survey. Columns 9 and 10 include people who encouraged or inspired students, and those who discouraged students in their study of mathematics, based on responses to Questions 16, 17, and 18 of the survey.
Comparing this information with data produced by the case studies will help the researcher discover more about students’ present situations, backgrounds, and future aspirations.
Table 6.1  
Summary of survey responses used to select interview participants

<table>
<thead>
<tr>
<th>ID</th>
<th>UNI</th>
<th>Course</th>
<th>Type of maths</th>
<th>Reason for selection</th>
<th>Reason for enrolling in this subject</th>
<th>Reason for enrolling in this course</th>
<th>Attitude towards mathematics</th>
<th>Encouraged by</th>
<th>Discouraged by</th>
</tr>
</thead>
<tbody>
<tr>
<td>S47</td>
<td>S53</td>
<td>BSc (Env)</td>
<td>CM</td>
<td>Low SES</td>
<td>Required subject for course as bridging maths</td>
<td>Returned to studies to upgrade job</td>
<td>Likes practical maths for use in future career life</td>
<td>Nobody; non-academic parents</td>
<td>Knows very few people who like it</td>
</tr>
<tr>
<td>S38</td>
<td>S53</td>
<td>BSc/BA</td>
<td>MM</td>
<td>Extrinsic motivation</td>
<td>It’s the only general course that doesn’t shut any doors</td>
<td>First degree is not suitable for employment</td>
<td>Enjoying the logic &amp; mathematical paradoxes</td>
<td>Impressive individuals; peers</td>
<td>Unenthusiastic parents &amp; teachers</td>
</tr>
<tr>
<td>S379</td>
<td>MCS</td>
<td>BSc (Phys)</td>
<td>CM</td>
<td>Peer influence</td>
<td>Prerequisite for astrophysics</td>
<td>Pursuing astronomy and Science Fiction</td>
<td>Doing it for Astronomy, doesn’t actively seek it out</td>
<td>Peers and university friends</td>
<td>High school maths teacher</td>
</tr>
<tr>
<td>S336</td>
<td>S52</td>
<td>BSc (Maths)</td>
<td>MM</td>
<td>Maths major &amp; likes maths</td>
<td>Enjoyment; being a logical thinker; good at school</td>
<td>Majoring in mathematics</td>
<td>Learn more because didn’t put enough work at high school</td>
<td>Parents instilled love of maths</td>
<td>People who laugh at maths</td>
</tr>
<tr>
<td>S377</td>
<td>MCS</td>
<td>BSc (Maths)</td>
<td>MM</td>
<td>Peer influence</td>
<td>Enjoyed school maths</td>
<td>Swapping musically for a new career</td>
<td>Swapped music for mathematics</td>
<td>Peers and lecturers</td>
<td>Mother hated maths</td>
</tr>
<tr>
<td>S354</td>
<td>S52</td>
<td>BSc</td>
<td>CM</td>
<td>Ethnicity; family influence</td>
<td>Enjoyment</td>
<td>Useful in other subjects</td>
<td>Likes understanding rather than memorizing</td>
<td>Parents</td>
<td></td>
</tr>
<tr>
<td>S384</td>
<td>S52</td>
<td>BBioMSc</td>
<td>CM</td>
<td>Influenced by culture</td>
<td>Interest; maths prerequisite</td>
<td>Influenced by grandfather’s extra help</td>
<td>One can never have too much maths</td>
<td>Grandfather; teacher</td>
<td></td>
</tr>
<tr>
<td>S369</td>
<td>S52</td>
<td>BSc (Env)</td>
<td>EM</td>
<td>High SES</td>
<td>Enjoyment</td>
<td>Potential use in the future career</td>
<td>Fascinated with the application of maths</td>
<td>Parents; teachers</td>
<td></td>
</tr>
<tr>
<td>ID</td>
<td>UNi</td>
<td>Course Type</td>
<td>Type of maths</td>
<td>Reason for selection</td>
<td>Reason for enrolling in this subject</td>
<td>Reason for enrolling in this course</td>
<td>Attitude towards mathematics</td>
<td>Encouraged by</td>
<td>Discouraged by</td>
</tr>
<tr>
<td>-----</td>
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<td>--------------------------------------</td>
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<td>-----------------------------</td>
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<td>---------------</td>
</tr>
<tr>
<td>S326</td>
<td>TEC1</td>
<td>BSc (Maths)</td>
<td>MM</td>
<td>Intrinsic motivation</td>
<td>Enjoyment and interest</td>
<td>Discover more; do postgraduate studies in maths</td>
<td>Loves maths; wants to invent new formula</td>
<td>Grandfather; self motivated</td>
<td>Peers' perception of maths not being fun</td>
</tr>
<tr>
<td>S350</td>
<td>SS2</td>
<td>BSc</td>
<td>CM</td>
<td>Offered second choice</td>
<td>Enjoyment; to enrich other subjects</td>
<td>Fulfilling mother's wish to become a doctor</td>
<td>Likes problem solving &amp; logical thinking skills</td>
<td>Teacher; mother</td>
<td></td>
</tr>
<tr>
<td>S339</td>
<td>TEC1</td>
<td>BEng (Chem)</td>
<td>CM</td>
<td>Offered first choice</td>
<td>Compulsory unit</td>
<td>Prerequisite for chemical engineering</td>
<td>Enjoyed maths in science, but not in engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S378</td>
<td>MCS</td>
<td>BSc (Phys)</td>
<td>CM</td>
<td>Influenced by culture</td>
<td>Prerequisite; core units in current course</td>
<td>Importance of science in identified culture</td>
<td>Belief in school that aptitude wasn't high</td>
<td>Author of Beauty of Maths (book)</td>
<td>Teachers; father</td>
</tr>
<tr>
<td>S87</td>
<td>SS3</td>
<td>BEng (Mech)</td>
<td>CM</td>
<td>Offered first choice</td>
<td>Enjoyment; part of course</td>
<td>Without father's support would have done humanities</td>
<td>Maths as motivator to try harder</td>
<td>Challenged by maths teachers</td>
<td></td>
</tr>
<tr>
<td>S126</td>
<td>TEC2</td>
<td>BSc (Maths)</td>
<td>MM</td>
<td>Extrinsic motivation</td>
<td>Enjoyment; salary &amp; market demand for maths</td>
<td>Wants to be skilled in maths, current major</td>
<td>Equal interest in maths and high salary</td>
<td>Impressive individuals</td>
<td></td>
</tr>
<tr>
<td>S142</td>
<td>TEC2</td>
<td>BEd (Maths)</td>
<td>MM</td>
<td>Intrinsic motivation</td>
<td>Aptitude in maths; skill for teaching; enjoyment</td>
<td>Preparation for maths teaching career</td>
<td>Likes direct answers of right or wrong with no confusion</td>
<td>Inspired by educated parents</td>
<td></td>
</tr>
<tr>
<td>S178</td>
<td>SS3</td>
<td>BEng (Mech)</td>
<td>CM</td>
<td>Compulsory &amp; dislikes maths</td>
<td>Doesn't particularly enjoy it; part of course</td>
<td>Mastery in maths is important in engineering</td>
<td>It was required for course, not happy with that</td>
<td>Peers</td>
<td></td>
</tr>
<tr>
<td>S391</td>
<td>SS3</td>
<td>BEng/BA</td>
<td>CM</td>
<td>Intrinsic motivation</td>
<td>Enjoyment; maths related to everything</td>
<td>Becoming engineer and need to utilising maths for job</td>
<td>Students don't get enough maths at primary &amp; secondary school</td>
<td>Inspired by physician parents</td>
<td></td>
</tr>
</tbody>
</table>

173
<table>
<thead>
<tr>
<th>ID</th>
<th>UNI</th>
<th>Course Type of maths</th>
<th>Reason for selection</th>
<th>Reason for enrolling in this course</th>
<th>Attitude towards mathematics</th>
<th>Encouraged by</th>
<th>Discouraged by</th>
</tr>
</thead>
<tbody>
<tr>
<td>S135</td>
<td>TEC2</td>
<td>BEng/ BSc (Maths)</td>
<td>MM Influenced by culture</td>
<td>Enjoyed at school</td>
<td>Just enjoying maths</td>
<td>Relatives; teachers; Self-belief</td>
<td>Father</td>
</tr>
<tr>
<td>S145</td>
<td>TEC2</td>
<td>BEng</td>
<td>CM Ethnicity; Influenced by family</td>
<td>Enjoyment, part of Engineering course</td>
<td>Always took highest level maths at school</td>
<td>Parents and relatives</td>
<td></td>
</tr>
<tr>
<td>S245</td>
<td>SS1</td>
<td>BSc/ BA</td>
<td>CM Ethnicity; Influenced by family</td>
<td>Taken as part of science courses</td>
<td>Parental support</td>
<td>Teacher; peers; individual</td>
<td></td>
</tr>
<tr>
<td>S261</td>
<td>SS1</td>
<td>BSc</td>
<td>CM Compulsory; dislikes maths</td>
<td>Taken as part of science course</td>
<td>Finished school 10 years ago &amp; needs it for current course</td>
<td>Found it irrelevant in day to day life &amp; laboratory job</td>
<td>Lecturer; teachers</td>
</tr>
<tr>
<td>S240</td>
<td>SS1</td>
<td>BEng Bio. Med.</td>
<td>CM Intrinsic motivation</td>
<td>Enjoyment; best subject at school; own choice</td>
<td>Becoming an engineer</td>
<td>Maths teacher; parents</td>
<td></td>
</tr>
<tr>
<td>S280</td>
<td>SS1</td>
<td>BA</td>
<td>EM Offered second choice Intrinsic motivation</td>
<td>Interest; good results at school; influence of peers</td>
<td>Complements major course of economics</td>
<td>Interested</td>
<td>Parents, teachers</td>
</tr>
<tr>
<td>S276</td>
<td>SS1</td>
<td>BSc (Advanced)</td>
<td>MN Intrinsic motivation</td>
<td>Enjoyment; utilising maths in future work</td>
<td>Gain a greater understanding of the world</td>
<td>The more maths learnt the more interesting it is Everything is maths – e.g. music, language</td>
<td>Primary &amp;secondary school teachers</td>
</tr>
<tr>
<td>S250</td>
<td>SS1</td>
<td>BA</td>
<td>EM Influenced by culture</td>
<td>Wanted to choose a variety of study areas</td>
<td>Influence of parents</td>
<td>Everything is maths – e.g. music, language</td>
<td>Parents; Self-belief</td>
</tr>
<tr>
<td>S264</td>
<td>SS1</td>
<td>BEng BioMed /BSc</td>
<td>CM High SES</td>
<td>Favorite/ best subject at school</td>
<td>Wants to have a career in maths</td>
<td>Interested by father’s help from young age</td>
<td>Parents’ constant encouragement</td>
</tr>
<tr>
<td>S294</td>
<td>SS1</td>
<td>BPsych</td>
<td>CM High SES</td>
<td>Part of course; did well at school</td>
<td>Mother would have disowned me if I did not do maths</td>
<td>A bit annoyed with having to do more maths</td>
<td>Inspired by psychologist mother’s stories</td>
</tr>
</tbody>
</table>

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6.1.3 *Sample distribution by university and mathematics sequence*

Although the selection of interviewees did not seek to show diversity in terms of universities, Table 6.2 shows that the 27 interviewees were enrolled across all six universities involved in the research and therefore represented a range of university types and locations. Similarly, all four types of mathematics sequences were represented.

**Table 6.2**

*Interview participants by university and mathematics sequence (N=27)*

<table>
<thead>
<tr>
<th>University</th>
<th>MM (maths major)</th>
<th>MN (maths minor)</th>
<th>EM (elective maths)</th>
<th>CM (compulsory maths)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sandstone 1 SS1</td>
<td>$276</td>
<td>$280, $250</td>
<td></td>
<td>$245, $261, $240, $264, $294</td>
<td>8</td>
</tr>
<tr>
<td>Sandstone 2 SS2</td>
<td>$336</td>
<td>$369,</td>
<td></td>
<td>$354, $384, $350,</td>
<td>5</td>
</tr>
<tr>
<td>Sandstone 3 SS3</td>
<td>$38</td>
<td></td>
<td></td>
<td>$47, $87, $178, $396</td>
<td>5</td>
</tr>
<tr>
<td>Multi-campus MCS</td>
<td>$377</td>
<td></td>
<td></td>
<td>$379, $378</td>
<td>3</td>
</tr>
<tr>
<td>Technology 1 TEC1</td>
<td>$326</td>
<td></td>
<td></td>
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6.2 Summary of findings for all 27 interviewees

Eccles and Wigfield’s Expectancy Value Theory of Motivation has been used as the theoretical framework in this part of the analysis (see Figure 4.1, § 4.2.4). Figure 6.2 shows the classification of interviewees’ responses, based on the same structure as Figure 4.1. Individual interviewees are grouped according to classifications of their responses with respect to Eccles and Wigfield’s Expectancy Value Theory of Motivation framework. This model was used as the basis for grouping interviewees by linking students’ answers to the categories utilised in each part of the survey. Students’ entire survey responses were reviewed when their answers to a particular part of the survey were not clear enough to decide their appropriate group.

Figure 6.2 is an elaboration of Figure 4.1, as well as a summary of the data collected from all 27 interviewees. In this figure, student codes have been allocated to each type of value evidenced in the interview data, so students usually appear in more than one place in the figure.
Figure 6.2. Interviewees’ responses classified according to the Eccles framework (N=27)

6.3 The case studies

To analyse interview data, an in-depth examination of a single example can be useful (Flyvbjerg, 2006). This enables detailed contextual analysis (Yin, 2009) of a limited number of students. In this case, one student from each of the 11 categories shown in Figure 6.1 was selected for in-depth analysis. This was done in order to
maximise variation amongst responses so that the complexity of students’
reflections on their decisions and aspirations concerning mathematics education
could be explored. The case study as a singular and unique event (Simons, 2009), as
explained in § 3.3.5, offers a significant capacity for understanding students’ holistic
perspective, leading to universal results (Stake, 1995; Yin, 2009). This conceptual
framework has also been used to organise the content of each case study, as
represented below using the subheadings: Expectation of success, Intrinsic value,
Utility value, Attainment value, and Cost value.

The case studies start with Student S47 and continue with a review of the
other ten cases. Each student belongs to one category as was classified by the
selection criteria (see Figure 6.1) but, as noted earlier, there is a likelihood of
overlap between categories as they are not mutually exclusive.

6. 3.1 Parents instil their interest in you – S47, SS3

As indicated in Figure 6.1, student S47 was selected for interview because he
indicated on the survey that he was from a low socio-economic background. S47
was from an “outdoor living” background, highly inspired by his parents’ nature-
friendly lifestyle. He was offered a scholarship while doing his first university degree
and working part time. He worked as an environmental manager and began an
undergraduate degree course studying in another city, during which time he felt a
lot of pressure from both working and studying full time. He then returned to his
hometown and decided to enrol in an environment-related course. As part of his
course requirements he had to take mathematics and refresh his secondary school
mathematics knowledge. At the time of the interview he was doing a Bachelor of
Environmental Science at SS3.

Expectation of success

The development of S47’s mathematics studies showed his need for
assistance at primary school, signs of mathematics anxiety at secondary school, and
also in his first university course. He remembered his parents’ help with primary
school mathematics:
And see, when I went through maths in primary school I was in moderation ... in lower level class. And I had a different workbook to other people because I really had a lot of difficulty grasping a lot of the maths and my parents had to take me through it (S47, P4, L29-34).

At secondary school although his initial fear ("trepidation about doing maths", P2, L18) diminished and he was relatively relieved (P2, L20), his lack of confidence arose during higher studies as he foresaw more maths on the horizon:

But I think later on there would have been [more maths] and that’s why I was worried (S47, P7, L12-18).

In the end he struck a positive note in relation to his recent course and explained:

But it seems to make more sense this semester; things are a bit more fresh (S47, P7, L12-18).

However, his last comment showed low expectation of success:

Just even trying to motivate myself so instead like you know I've only got a year and a half left it’s a lot faster for me to just push through it full time (S47, P9, L; 24-26).

Taken together, these remarks suggest that S47 was not a high performing student. He had struggled with his mathematics learning and had “pushed through” despite low expectations of success.

**Intrinsic value**

Student S47 first talked about his early secondary school years when mathematics was interesting despite his fear in the beginning:

I went into it with trepidation about doing maths, but by the end of it I was actually – I found it really interesting and was enjoying it (S47, P1, L18-20).

However, there was some discontent in taking Mathematics B, a middle-level mathematics subject in Queensland, in mid-secondary school:

I had to do the Maths B, I wasn’t very happy about it (S47, P3, L38).

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4 S47, P4, L29-34 refers to page 4, lines 29 to 34 of Student 47’s interview transcript
His effort at university failed, demonstrating how the structures and processes of university study (e.g. assessment regimes) can stifle and diminish intrinsic enjoyment when a student is struggling:

I did Maths A. I loved algebra, I really enjoyed it but I thought it was a fun and the problems and everything. And this time around because I was so stressed and rushed in it trying to get – because we had an assignment every week I actually hated it by the end (S47, P7, L41-45).

Eventually, his interest and joy vanished and his desire to learn mathematics declined:

I’ll never do any more maths or statistics. Just because I’d rather do things – like I want to do (S47, P8, L39-40).

In the case of S47, despite an intrinsic enjoyment of mathematics as a field of study, the assessment requirements of university study in mathematics diminished his motivation.

**Attainment value**

Student S47 demonstrated the attainment value that he derived from mathematical study through the following story, where he explained that his persistence in becoming an environmentalist made him take a large component of statistics:

Well initially I wanted to be an environmental planner ... and I went and did the traineeship and I've worked in government and that’s where I work at the moment a [state environment department]. So I've done all the lower level stuff for 7 years and ... then I realised I didn’t quite want to do it. It's interesting you know as you realise that probably wasn’t quite what you wanted to do and then I worked at the GIS and mapping and stuff like that is what I want to do. It started as a large component of statistics (S47, P5, L22-30).

Student S47 provided an example of his parents’ influence, or what Eccles (2009a) refers to as the *socializers* who influence people by their own experiences over time, and tried to authenticate his dream of the person he wanted to be:

But my parents are very outdoorsy, very conscious of environment conservation. So if you have parents like that they instil that in you – so if
you had musical parents I suppose you would be a musician (S47, P5, L39-41).

So, further to his intrinsic enjoyment of mathematics, mathematical study also aligned with S47’s aspirations to live a particular kind of life, with particular interests in terms of a career that mathematical study would serve. In this way, mathematical study provided both attainment and utility value.

Utility value

For S47, mathematical study was necessary to pursue a career in relation to “GIS and mapping” and was a requirement for admission into a Bachelor of Science. While he decided to complete a course in science, and hoped he would be able to meet the requirement, he explained:

Getting into a Bachelor of Science you need to have done Mathematics B and chemistry or physics, and I didn’t have either of those. But I thought I had everything when I left school seven years ago (S47, P4, L29-30).

However, he looked very well placed in studying mathematics to satisfy his recent course requirements and regretted not giving more attention to his mathematics before commencing this course:

And I’m in that now. [When] I was in Environmental Management I couldn’t get any of my credits from my previous study so I started again, doing the Maths B and the chemistry was part of it. So now I’m transferred I’m over the moon but I wish I’d probably taken more attention to the maths (S47, P4, L7-11).

In spite of his low level of success, S47 demonstrated a high level of persistence in pursuit of a course of study that included mathematics.

Cost value

Losing time and energy is listed as symptoms of cost value in the Eccles model. Student S47 worked and studied for seven years until he achieved his goal and the course that he wanted to do. Although he skipped mathematics during school, he was now enrolling in a bridging course to achieve his ultimate goal of becoming an environmentalist. In his interview he stated:
[The university] had one mathematic subject you could do externally and I was trying to do that and with my job and you know you get up – you just start at – your days start at 5.00 in the morning and you're not home till 6.00 and then you're working long weekends and stuff like that. And I mean I could've tried to make more time but maths – trying to study externally it's one of those things not – if you're not familiar with it, it's really not easy (S47, P3, L14-20).

Time limitation is a cost value for completing his course. Nevertheless he was not sure if a 13-week mathematics course would provide him the amount of mathematics he needed:

I wish there was more time to do it because it was only 13 weeks and you're doing Year 11 and [Year] 12 maths that goes for 2 years so it's quite fast paced (S47, P1, L20-22).

In summary, although S47 was selected for the interview based on survey responses suggesting a low socio-economic background, this aspect of his background was not a strong feature of his story about his pathway into, experience of, or reasons for studying mathematics at university. Instead his job aspiration of becoming an environmentalist triggered utility value as he was taking mathematics and statistics in spite of demonstrating low intrinsic value towards these subjects.

His lack of financial support from early schooling to the end of school, and through his initial time at university, influenced the pace of achieving his goal and completing his course of study. One example was the interruption of his first university course because of using a scholarship fund, and later working and studying full time and during weekends. A different financial situation may have made his pathway easier through such things as paid tutoring and the extra time he would have had if he had not needed to work.

### 6.3.2 I can do whatever I want to do – S336, SS2

Student S336 was invited to participate in the interviews due to her liking mathematics and her intention to major in mathematics – that is, her intrinsic motivation. She was doing science, majoring in mathematics and chemistry, in addition to taking another undergraduate degree in drama. She had her musical instrument with her when she arrived at the interview as she planned to go to work
after the interview. She taught music at a primary school, besides studying at university.

Talking passionately about herself – her logical thinking, multiple talents and friendly church community that admired her skill in handling different things – she suggested that people could do anything they wanted to do, as she did. However her secondary school experience was not completely successful as in some stages she didn’t feel she completed her tasks and tests properly. Her parents – father working as a college director with a PhD in theology and mother recently enrolled in a university course – had a big influence on her enthusiasm toward education. She was doing science at S52 and was the only member in the “liking and majoring mathematics” category shown in Table 6.1.

**Expectation of success**

Student 336 was planning to major in mathematics and sub-major in chemistry, as she believed in her strength in logical thinking and handling her plans:

> My plan is to major in pure maths with a sub-major in chemistry. You have to have a sub-major outside your major (S336, P2, L17-18).

In the next quote, S336 showed her mathematical skills, and the value of engaging in tasks until the result or solution is achieved:

> I like the logic behind it and I think it’s really cool when you get to something [in mathematics] and you say “Ah” – say you’re doing integration and you’re like if I substitute this it just works – you know what I mean and the fact that it works for everything – that it’s something that can be applied anywhere (S336, P1, L36-42).

Another example of her high expectation of success was demonstrated in the next quote where she referred to her self-efficacy and ability in shaping her identity, and being able to do anything she wanted without the influence of others:

> A lot of people when I tell them my plans for the future go ... “If you’re a maths [person] you totally can’t be an actress” – and I am like “Well that’s wrong – I can do whatever I want to do” (S336, P5, L15-20).
There was no suggestion of any doubt in her abilities in handling different courses and working in the meantime.

**Intrinsic value**

Student S336 demonstrated her enjoyment of doing mathematics tasks as she became very happy doing a mathematics problem. This is called *situational interest* (Eccles, 2009a), and showed personal interest while admiring mathematics as the clearest form of logic:

I suppose it’s an outlet because it’s the most – to me it’s the clearest form of logic. In other areas thought kind of gets in the way or emotion gets in the way. I mean you can get very happy over a maths problems but it doesn’t get in the way of the maths. There’s always going to be the maths kind of being truth – if that makes sense (S336, P3, L7-12).

She mentioned her joy of working through mathematics concept and added:

I really like it. I think it’s really cool. I enjoy the working more than the answer. I find the concept of working through a problem cool (S336, P2, L36-38).

The well known quote of Bertrand Russell might well be adopted here in summing up the pleasure she found in mathematical thinking and its beauty as “Mathematics, rightly viewed, possesses not only truth, but supreme beauty, a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature” (cited in Wigner, 1960, p. 1).

**Attainment value**

In terms of personality and capabilities S336 talked about her secondary school’s multifaceted curriculum shaping her personality and capabilities toward her values:

Because I didn’t want to have an entirely science-based curriculum in high school, I needed an outlet because I’m very creative as well and without drama I would not have got through Year 12. I wouldn’t have worked (S336, P4, L6-9).
Her attainment value was more visible through the social script she presented regarding proper behaviour in relation to a group of her academically successful friends:

I got in with a very good group of friends. In my friendship group from Year 12, one is doing science ... other is a doctor and my friend – she is doing maths teaching and PE teaching ... and one of my other friends is doing physio, so I suppose I fell into a group that was very [maths] driven and that liked learning which was really helpful because it’s nice to be able to share that with someone (S336, P3, L22-28).

In terms of motivation she recalled her academic parents and their focus on education:

They think I’m a little bit odd but they’re happy with that ... from a young age they’ve loved helping me learn and I’ve loved to learn so it worked really well, so I suppose they said “Hey, if it’s maths that you like, do maths” (S336, P4, L45-51).

Student S336 was confident about what she wanted to be in the future, utilising her multiple talents. She liked mathematics, music and drama, and wanted to work in these areas saying:

I’m planning a grad dip so that I can become a maths teacher and a music teacher and then I’m hoping to become an actress (S336, P4, L25-28).

Based on her belief in self-capability and talent in mathematics, music and drama, she was able to frame her future confidently.

**Utility value**

Student S336 thought highly of logic and her mathematical ability in facing everyday life situations and problems:

Well often I’m very scatterbrained but I can apply logical processes and it makes life so much easier (S336, P2, L27-28).

Then she explained how well her mathematics tasks fulfilled her needs in constructing her plans for life and also in her teaching job.
I have kind of mapped out my degree I suppose. I suppose I see logical thinking not only in an organisational sense where it’s important to have each step in line, but I suppose it also helps me in teaching [her part time job] (S336, L22-29, P6).

To portray the complexity of how she saw herself and how she believed others saw her, and the implications of her mathematics study, she referred to her father’s help in mathematics homework:

They think I’m a little bit odd but they can cope with it. I was a little bit frustrated because my sisters always had Dad helping them with maths, but they never did Year 12 maths, they had Dad helping them through their maths but because I did Year 12 maths and now I’m doing uni maths I’ve surpassed him in maths which is not cool anymore – I can’t get help (S 336, P4, L49-54).

So her decision to study senior mathematics and university mathematics had implications for her family relations, as did the way in which she believed in herself.

Cost value

One suggestion of cost value for S336 was losing her father’s attention and help in mathematics as she surpassed his mathematics ability after being admitted to university and became involved in higher-level mathematics. However, her difficulty with managing the time needed for mathematics assignments had also affected her results and confidence in achieving as well as she had expected:

If I want to do well in maths it probably is very time consuming. I was upset there – I lost my first mark in my assignment. We have like weekly assignments and it was like linear algebra (S336, P7, L29-32).

Cost value did not change S336’s decision to do mathematics as she still wanted to achieve a higher grade on her mathematics assignments.

In summary, based on her responses to the survey, student S336 was selected as an example in the orientation towards maths category of a student majoring in mathematics and liking mathematics. Although she demonstrated a considerable amount of interest in the subject through her choice of university course and in her interview, attainment value dominated her reasons for learning
mathematics, and she had lost marks towards her current mathematics assessments because of other study and work commitments. She was trying to show people that it is possible to do everything you wanted while trying to build her identity as a mathematics and music teacher, and also an actress.

### 6.3.3 At 15 I left my parents’ house and became a street kid – S377, MCS

Student S377 was chosen because of the influence of friends on her decision to return to study at a mature age. She was a musician, studying science and majoring in mathematics, after many years working and struggling with her life’s difficulties. She had to leave home at 15 because of her mother’s disagreement with her interest in mathematics and trying to force her towards medicine. She spent a few years learning and teaching music, until around age 30 when she became unwell and changed her life path from musicology to mathematics, with encouragement from her friends. Satisfied with her first year results she was planning to do her postgraduate degree upon her lecturers’ agreement. She was thankful to have someone listen to her life story and happy to talk about her experiences openly.

**Expectation of success**

Student S377 showed high expectation of success after passing the bridging course part of the first semester with a high score:

On my equivalent bridging course I got 99% for it, so I was very very happy with that. And I've just survived my first semester of uni and all my marks are in the high 90s and I love calculus, I love algorithms (S377, P4, L6-8)

She then explained how after getting those marks her study consultant encouraged her to do postgraduate study:

The course consultant said “you know I really want you do a postgraduate study” and my professors are saying “mm, you know keep doing what you do with your path” (S377, P4, L16-19).
Student S377 was keen to continue her mathematics studies to a postgraduate degree and was thinking of swapping to mathematics from computer science or physics:

I am currently enrolled in a double degree, I thought that I would do maybe computer science or physics but ... they [the lecturers] say anybody can do mathematics. I’m scared about [being] too old you know but getting me through faster so I can do postgraduate study in mathematics (P377, L16-22).

In spite of uncomfortable past experiences S377’s confidence in completing her double degree course and commencing her postgraduate study after that showed a high level of expectation of success.

*Intrinsic value*

Through her interview S377 re-iterated her enjoyment of mathematics several times:

I just enjoy mathematics S377, P4, L21).

In her story she pointed to her willingness to learn mathematics at the early age of eight and the discouragement of her mother, who was not supportive:

I was discouraged from studying mathematics from a young age, but I can remember being 8 years old and desperately wanting to know what algebra was (S377, P1, L42-44).

She did not give up and made her mother bring her some books:

I had to badger my mother into bringing me home some text books from you know 8 levels. Finally she did and I worked from them by myself, so when I was eight I was teaching myself Year 8 mathematics out of text books (S377, P1, L49-52).

She also related her strength in music, the course she substituted for mathematics after school, which she related to her mathematical ability:

My strengths in music ... Harmony is extremely mathematical figure base feel like it’s the same part of my brain that I’m exercising when I do musicological analysis and when I’m doing mathematics (S377, P4, L44-49).
Although there was no particular quote conveying her attainment value, Student S377’s personal story of adversity, passion and struggle seemed important.

Utility value

With her musicology skill S377 was still not sure of a financially secure future:

I’m a passionate musicologist but the problem is being a musicologist, there is no job description ... the departments of the country is getting waddled down to nothing, there’s no job (S377, P3, L: 28-32).

She was hoping to develop her career with her course as well as improve her health issues:

Lots of therapy and we talked about things and we ended up coming to, me not being happy with my life and my career (S377, P3, L9-10).

Cost value

Student S377’s was a story of struggle amidst extreme adversity. There were four main sources of cost associated with her pursuit of mathematics: the disapproval of her mother; the financial time commitment required to support her university study; the time required for higher education; and anxiety about her current pathway.

The cost value S377 perceived through her mother’s disapproval was clearly shown during the interview when she talked about her mother’s discouragement several times:

I was discouraged and she [mother] didn't like me doing it [maths]. It seemed to annoy her so I stopped and – I know my mother’s very odd (S377, P1, L56-57).

Student S377’s mother’s disagreement with her involvement with mathematics was apparently related to a traditionally approved profession:

[My mother said] you need to be a genius to study it [maths] ... she was pushing me towards being a doctor. There was a very very controlling Jewish
traditional upbringing that was very, in some ways quite traditional and very pushy and very difficult in my mid-teenage years (S377, P2, L14-16; P3, L5-8)

The financial commitment required for S377 to support her university study was a second aspect of cost value incurred by her choice of course because she had to leave home at 15 and live on her own doing all sorts of things:

When I was 15, I left my parents’ house and became a street kid around the country and did all sorts of things ... that affected my choices whether I would study mathematics. I think in some ways if I hadn’t come from a history of domestic violence I probably would have gone straight into mathematics (S377, P2, L38-41).

The time commitment for her university studies was the third part of the cost value, demonstrated by her desire to get back to her life-long goal and enrol at university for a science degree majoring in mathematics, after psychological trauma, insomnia, and disappointments:

I've kind of failed at everything ... and as much as I'd succeeded at music, I also sort of know in my heart that I'm not a very talented musician (laughing)... where I had all the opportunities and all the talent and all the intelligence in the world [and missed it] I think I'd probably do mathematics (S377, P3, L8-21).

Anxiety about her current pathway, for example about financing her university life, was the fourth feature of cost value as S377 has had to work full time while doing a university course:

I work pretty much full time to support myself through two degrees ... I work 12 hours a day, every day and – I'll go from five hours of lectures to five hours of piano teaching. I work all day Saturday teaching piano for 8-10 hours and some days I usually have to do homework (S377, P4, L54-57; P5, 1-8).

She also had to deal with anxiety concerning her age as she feared being old for what she is doing:

I'm scared about too old you know (S377, P5, L22).
The cost value expressed throughout S377’s schooling and then transition to university appears to be outweighed by her strong *intrinsic value* of mathematics that ultimately influenced her decision to do mathematics at university.

In summary, Student S377 was chosen for peer influence as shown in Figure 6.1, asserting her friends’ impact on her decision in swapping her occupation of ten years to studying a science degree, majoring in mathematics. She evidently had very strong abilities in mathematics and derived a very high level of intrinsic value from her mathematical pursuits, but had encountered extreme barriers and costs, primarily in the form of her mother’s disapproval and other negative consequences related to that.

Her satisfactory results in the first bridging course subject illustrated a high expectation of success that had taken her to a postgraduate course in mathematics. This would go towards compensating for the various costs she had incurred in the past, in addition to her fear and anxiety about dealing with her current pathway. Her expectation of utilising her degree in finding a good income showed the utility value attached to her decision to study mathematics.

**6.3.4 It’s hard to document your own personal preferences – S384, SS2**

Student S384 was selected for interview based on evidence in the survey of the positive influence of his cultural background on his decision to study tertiary mathematics. He was selected as a case study for a number of reasons including: his inspiration from his parents, who finished their own studies at his university and considered it the best university; the impact of his parents on his first choice of course; and, most importantly, his belief in having “mathematical ability” as an inherited from his grandfather, who worked at the Department of Education as a mathematician.

Student S384 wished to continue his university studies under the HECS scheme and did not depend on parental financial help after they had sustained expensive private school bills. He was doing biomedical science, minoring in music at SS2.
*Expectation of success*

Student S384 confidently welcomed mathematics subjects in his course and perceived that he had a natural ability in mathematics:

Maths comes to me naturally so of course I'm going to try and do as much possible (S384, P1, L26-27).

He explained how university mathematics related to the advanced mathematics subject he had done at school without any problem:

It’s an extension of specialist maths from high school, so it's basically building on what we did there ... Yeah it wasn’t too challenging and for a lot of other students I know it was, but for me it was alright (S384, P2, L3-4; 26-27).

He believed his recent mathematics subject built directly on the specialist mathematics he had done during Year 12, expressing his high expectation of success:

Well I think the maths course that I'm doing now ... is very structured to come from specialist maths, they're the same topics, it's just here's what you learn in Year 12 and now we’re going to build on that sort of thing (S384, P5, L8-11).

The above quotes further suggest S384’s high expectation of success.

*Intrinsic value*

Student S384 enjoyed mathematics, believing in an initial “click” that produced a joy when studying it:

I think you have to have that sort of initial click I guess to enjoy maths and to enjoy studying maths. ... I’m going to have a bit of a re-think because it's sort of what I, I've enjoyed those subjects the best, all the maths ones (S384, P4, L40-41; 50-52).

He spoke of his personal preference and interests similar to S336:

Maths makes sense, I like that about maths ... there’s always a yes or no answer it’s a right or wrong. (S384, P1, L35-37)
He then explained about his interest in mathematics and how teaching the subject in an effective way would help develop interest towards it and reduce rote learning that makes students tired and uninterested:

But enjoying [mathematics] I think is how people teach you because if it's something that you just rote learn, do over and over and over again, it's not that much fun. But if you have a teacher who is passionate and makes it funny, like adding anecdotes to it or something like that, it's just a lot more enjoyable and people are more likely to continue doing it if the environment and the way they are taught it is fun and interesting (S384, P1, L12-18).

Noting the initial “click” and generating enjoyment in mathematics by quality teaching provided evidence of the high intrinsic value Student S384 associated with mathematics.

**Attainment value**

Student S384’s interview demonstrated a high level of attainment value derived from mathematical study, as well as from his particular university choice. S384 talked about his grandfather’s role in providing him mathematics problems during his school years:

My grandpa was my main influence; he’s a fantastic mathematician. He worked at the Education Department and he used to come over and give me all these problems, even early years of high school, and we’d do them later in like Year 12 (S384, P1, L41-45).

Later he explained how his grandfather provided him challenging mathematical problems on material that was not offered by school, which he solved and sent the back to get marked (P3, L28-33).

While admitting the influence of his grandfather’s encouragement S384 also admired his own ability in mathematics as well. He spoke about the connection between any sort of talent and certain genetic dispositions:

Yeah I think there’s a certain genetic predisposition for any sort of ability, but then there’s also the environment as well. So if someone around you is good at maths, you’re more likely to [also be good], even if you’re not a direct relative (S384, P, 3, L7-10).
The above quotes suggest that, like his grandfather, S384 saw himself as having innate mathematical ability beyond that of his peers. Mathematical study was consistent with the way S384 saw himself, as having superior, innate mathematical abilities, which was presented as part of a family tradition and possibly a genetic legacy, following his grandfather and becoming part of his identity.

**Utility value**

Student S384’s current course was his second choice. He was still interested in his first choice and wanted to use his subjects towards prerequisites for medicine:

I’m leaning towards doing med when I go to the undergraduate course, but I did a unit of statistics as well (S384, P5, L20-21).

Considering the evidence regarding high expectation of success and strong intrinsic and attainment value, the effect of utility value looks secondary in this case.

**Cost value**

Student S384 compared university lecturers and secondary school teachers in terms of receiving one-on-one help:

But [at university] there are so many more students that you can't get that same one-on-one help if you need it. So in that regard I guess it's a little more challenging, but its okay so far (S384, P5, L43-44).

S384’s other interests, for example music, restricted his time and space in his chosen course, forcing him to recognise the cost value of studying mathematics:

But unfortunately I've got a whole lot of other interests as well; I'm also doing a Diploma of Music .... So in terms of my course I can only do a few units over the whole thing (S384, P1, L28-30).

The limited help from the university in supporting students and time allocated for music classes were costs reported by Student S384.

In summary, Student S384 had high expectation of success and attributed a high intrinsic value to mathematics, as well as demonstrating high attainment value through the mathematics instruction and extra activities he had received from his
grandfather. Student S384 believed in his mathematical ability, which strengthened his confidence in his mathematics studies, course choice, and future plans. He was also enduring some costs, such as coping with his lecturers’ availability and finding adequate time while trying to utilise mathematics in his major course of biomedicine.

### 6.3.5 I sometimes scare people – S326, TEC1

Coming from a mixed Scottish and Australian background, with a teacher and a metal worker as parents, student S326 was majoring in mathematics at TEC1. He was studying science and had enrolled in eight subjects of mathematics in his first year of university. In response to Question 11 on the survey, he showed high interest and enthusiasm towards the subject:

I'm teaching myself other topics in mathematics outside of class. So, I’d be more than happy if I discovered that I had more to learn about mathematics (S326, Q11).

Furthermore, his past studies at secondary school and future plans were all mathematical. S326 was self-motivated and determined about what he was doing:

I am self-motivated. I’ve always been good with and enjoyed mathematics, and by the time I was in Year 12 the majority of my classes were mathematics. It just seemed natural for me to continue to learn mathematics at a higher level (S326, Q16).

He was chosen for a case study because among his group of students (S142, S240, and S276) he stood out as having the highest intrinsic motivation towards mathematics.

When first contacted by telephone, S326 did not make an appointment and asked for a bit of time. He then called me back after a few days explaining how important the interviews about mathematics were to him and why he needed to think about it and pick an appropriate time. He had a book on advanced mathematics, together with pencil and paper, when he came to the interview. This interview lasted significantly longer than the other interviews. After the interview, he showed me the mathematics book as well as a mathematical formula that he said was his own invention.
**Expectation of success**

Student S326’s past experience showed gradual growth in his expectation of success. His secondary school memories of learning mathematics around Year 10, followed by the evolution of his interest and skill in Years 11 and 12, together with his increasing levels of engagement with and even the use of “easier” mathematics classes to experiment with his “own things”, showed how his expectation of success proceeded through years:

Around Year 10, I started to really grow into it. In Year 11 I was quite adept with numbers, and had the opportunity to do more advanced stuff at school, and in Year 12 I would spend most of my time in the easier maths classes, just experimenting and doing my own thing to see what else I could learn myself (S326, P2, L3-7).

Factors of self-competency (an element of expectation of success) such as *personal relevance, familiarity and novelty, high activity level together with comprehensibility* (Eccles et al, 1998) dating back to S326’s secondary school experience can be seen in the above quote.

Further in confirming his high expectation of success, S326 talked about challenging himself as a way of responding to what he saw as “easy” or “boring” content:

Well I know I get bored with what we’re doing in class or in the lecture, so I will stop listening and go off (S326, P5, L55-57).

Expecting to do well in mathematics influenced S326’s decision to follow a routine program so he had initiated his own pattern of learning.

**Intrinsic value**

Reviewing S326’s expectation of success revealed his high interest in mathematics. The next quote demonstrates the kinds of interests that were linked to the massive intrinsic value S326 attributes to mathematics. S326 compared the beauty of mathematics to the pleasure that can be received from a delightful piece of music, both impossible to convert into words. He talked about the appealing intrinsic beauty of the “art of mathematics” and quoted from Paul Erdös:
Why are numbers beautiful? I cannot tell you any more than if you can tell someone that Beethoven’s 9th Symphony is beautiful. If you don’t believe it, then no one can explain it to you. There’s an inherent beauty in the art of mathematics, which really appeals. (S326, P1, L44-48)

This high level of appreciation and enjoyment suggests a high level of intrinsic value attributed to mathematics by S326, intrinsic value that in turn had elevated his engagement and eventually influenced his choice of mathematics at university. This is what Eccles (2009a) calls stable evaluative orientation, which is based on personal interest. Personal interest as opposed to situational interest is connected to engagement and can be seen in S326’s study and career aspirations.

Student S326’s situational interest in the inherent characteristic of mathematical tasks appeared when he spoke of the beauty of mathematics, this time related to the task and what he felt about engaging with it:

The beauty of mathematics is that, a part of it anyway, lies in the fact that you’re either right or you’re wrong (S326, P5, L37-39).

This type of comment about mathematics was also made by other students who were interviewed. For example Student S142, who was teaching both science and humanity subjects, expressed a lack confidence evaluating his own work. He said he could “curve them [his maths students’ results] all to make it fit a bell curve” (S142, P1, L34) and liked the fact of having “right” answers in maths and not “kind of right”, which is the norm in humanities subjects and which upset him in a lot in secondary school. A similar appreciation of the character of mathematics, albeit to a lesser extent, was evident in responses by other students, such as Student S384 above who said: “there’s always a yes or no answer. It’s a right or wrong”; and Student S336: “to me it’s the clearest form of logic ... There’s always going to be the maths kind of being truth”.

The experiences mentioned above, according to researchers such as Martin (2006), Upadhyay and Kumar (1010), and also Guay et al (2010), come from when a student derives pleasure in solving a mathematical problem, with the enjoyment of solving the task motivating him or her intrinsically. The source of pleasure that lies in the activity is a type of motivation that has real value in learning, as well as
creating spontaneous and sustained attention, and interest throughout the problem-solving activity.

**Attainment Value**

Student S326 spoke of the seven millennium prize problems of the Clay Mathematics Institute (see Jackson, 2000). His consistency in doing well and allowing himself to express or confirm important aspects of self led him to think about this extremely high goal in relation to attainment value:

Series of originally seven maths problems that are quite old and no one has close to proving them or solving them [one of them was solved in 2010]. If they are solved, then they have huge ramifications for all kinds of areas of science and computers and maths, and each of them has a one million dollar bounty on a solution for it (S326, P5, L15-20).

Student S326 then mentioned a secondary school teacher who made him enjoy learning mathematics and helped him to experiment with mathematics. He related this to his current course and possible future postgraduate studies, with the goal of eventually working as a researcher in mathematics:

I think, at the moment ... I finish my degree, so go on to do postgraduate study and then research in mathematics (S326, P. 2, L30-33).

S326 then linked his tasks to his own preferences and identity:

My teacher for that [specialist maths] was probably the biggest influence on me in terms of that stuff (S326, P3, L18-20).

Student S326 referred to his grandfather as a very intelligent man, identifying the role of his intelligence as motivating his seeing mathematics as part of his personal needs as related to Eccles’ definition of attainment value:

My grandfather is a very intelligent man who never had the opportunity to have a higher education, but he reads all kinds of obscure science books and stuff in his spare time, so maybe I get some of it from him. (S326, P5, L5-9).

Eccles and colleagues (Eccles et al., 1998) believed that activities that fulfil personal interests, personal values, and personal needs are linked to an individual’s attainment value. Attainment value thus shapes the identity of one’s image of ideal
self. Student S326 pointed to the book he carried to the interview and proudly claimed that he wanted to solve the problems although, he said, they were rather hard, again confirming his high attainment value:

Yeah I’m trying to get through it. It’s impossibly hard, like a single question will take me 3 hours to work out how to solve it, so I’m only very near the start, but it’s a lot of fun (S326, P3, L46-49).

This relates to Connell, Spencer, and Aber’s (1994) claim that need for competence, relatedness, and autonomy are three basic needs that influence attainment value. In maintaining his approach to competency, S326 authenticated his need for autonomy and prioritised university mathematics as stimulating compared with school mathematics:

In high school in that there’s not really that much call for independent thought or challenges, so you just have your question. It’s just a matter of identifying what process you need to follow, just follow the steps, and there’s your answer, which is quite frankly boring and not really mathematics. Whereas, as I said before, computing and professional practice required you to think independently (S326, P3, L4-10).

Student S326 expressed a very high level of motivation for mathematical study as a combination of a high expectation of success, a high level of intrinsic value, and also a very clear self-image as someone who actively worked hard in the field (following his grandfather), seeking mathematical challenges and engaging himself with high level intellectual work.

Utility value

While admiring mathematics for its beauty, S326 extended intrinsic value to getting access to mathematics’ utility value and wide applications:

Mathematics has a very, very, very broad range of different applications, so people in my degree go onto work in things; everywhere from banks and finance through to working further – CSIRO (S326, P2, L17-20).

He believed in his course’s marketability, which reflected its utility value and stressed how important the course would be in leading him to his future goal (Eccles et al., 1998):
The fact that I could go into a degree which gave me a whole bunch of different options about what I wanted to do after I finished was a really appealing aspect of it (S326, P2, L23-26).

Student S326 was fully aware of the demands for his chosen course as he was progressing in his field and wished to utilise his knowledge and expertise in the future.

**Cost value**

Fear of social consequences of success and rejection by peers was an aspect of cost value mentioned by Student S326:

> The faculty, I mean is a bit of a mixed bag. You’ve got people who openly tell me to my face that I sometimes scare them; through to I need to get a life, hobby, job, and girlfriend, whatever... (S326, P6, L11-14).

However, these responses by peers equally could have been an important and valued part of S326’s identity as a mathematics “nerd”, although it indirectly referred to here as what he had missed as the price of doing well in mathematics.

In summary, a close look at Student S326’s interview indicates his high expectation of success by teaching himself and exploring tasks in detail, his high intrinsic value in his love for mathematics, and high attainment value as reflected in his constant aspiration to become a mathematician like his grandfather. He also claimed some cost value in terms of peer empathy that didn’t bother him, and to utilising his mathematical knowledge to have a profitable career. Therefore S326 showed a high sense of self-efficacy in doing mathematics, exhibiting a large amount of “interest” (Schiefele, 1996) and “enjoyment” (Ryan & Deci, 2000).

### 6.3.6 Maths concepts are mirrored in nature – S350, SS2

Students S350 and S280 were chosen for interview because they were studying mathematics as part of their second choice of course. Student S350 was selected for the case study because he found out his second choice would lead him to a bachelor’s degree in pure mathematics, something he liked but was not able to do as a first choice. His case was also chosen because he hoped to do medicine after
completing his pure mathematics degree. He was doing a Bachelor of Science degree, his second choice, at SS2, after he missed out on medical science due to not meeting the entry requirements.

*Expectation of success*

Student S350 was confident of his ability in mathematics and his competence in undertaking his choice of study. He did not foresee any hardship or challenges in completing his major course in pure mathematics, because he said that he had always “quite good at maths”:

Well maths has just always interested me, well because like in the lower levels of maths, I was always – if I can be so not humble – I was always quite good at maths, like in younger year levels and such but then in about Year 11 or 12 in high school, yeah I really started getting interested in the like concepts in maths (S350, P1, L33-37).

Missing out on his first the second choice apparently directed him towards an even more promising destination where he could complete a mathematics degree, utilising his mathematical skills, and then start doing his first choice:

My first choice was the bachelor of biomedicine ... interestingly there’s not actually an option for further study in maths in that degree, as in [current course] because you can’t do a bachelor of biomedicine majoring in maths whereas in science you can, and since I’ve been in the bachelor of science I’ve actually decided that I might want to go on and major in maths (S350, P1, L15-23).

S350 then explained his appreciation of mathematics concepts that extended to his educational aspirations in achieving, doing, and inventing different things:

It [maths] it’s either equal or it’s not, I guess, but I don’t know just more appreciation of concepts ... how they’re sort of mirrored in nature and stuff, ... and how maths isn’t just something that a bunch of old professors thought up at a university one day, but around us as well in the world and helps us achieve things and do things and invent things (S350, P5, L2-7).

Student S350’s high expectation of success had led him to take advantage of what might have been seen as negative circumstances, by converting the order of his
preferences when he was not able to complete both courses because of different faculty rules and regulation barriers.

*Intrinsic value*

Student S350 explained his enjoyment and interest in mathematics in the following quote. The notion of intrinsic value that results from both enjoyment and interest in activity (Wigfield, 1994) is visible in his memories of primary to secondary school. His interest in mathematics grew from both aspects of situational interest – mathematics lessons becoming more interesting – and personal interest – suddenly having eureka moment in mathematics – and the stable orientation of value toward certain domains of activity that one enjoys (Eccles, 2009b):

Because they [maths lessons] started to get more interesting than just adding up all together. ... Yeah I just really liked the concepts ... I like something [that] clicks in my head about maths and yeah I just really enjoy that feeling, when you suddenly have a [n] eureka moment in maths and understand (S350, P1, L33-41; P4, L7-9).

S350’s secondary school teacher enhanced his interest:

In first semester my first year, that was kind of just growing on the stuff, the conceptual stuff that I was talking about before, that I really liked and I think in year, it would have been, yeah just Year 12 my maths teacher was yeah – he was very good at maths and he was very passionate about it too, so that really helped my interest in maths and really enhanced it as well (S350, P2, L5-10).

S350 mentioned enjoying solving problems as well as enjoying the mathematics concepts. He knew his power and was proud of having done a lot of mathematics with pleasure:

I really enjoy it – the ideas and concepts and I also like solving problems – like I’ve kind of learned to enjoy it because I mean when you say like maths problems to most people they probably don’t think of finding enjoyment. But yeah as I’ve done a lot of maths through the years I’ve kind of – I’ve sort of grown to enjoy it in a way, like just the solving of problems (S350, P2, L3-8).
Student S350 was similar to students S336, S384, S326, and S142 in that they all enjoyed solving mathematics problems, deriving strong intrinsic motivation (Guay et al., 2010).

**Attainment value**

Student S350 spoke about his childhood passion and interest that built his positive attitude towards mathematics through the years as something that “sort of came natural to me”:

I’m pretty sure there would have been a time, maybe in my childhood when I would have enjoyed it or like something important that made me like it but I can’t quite remember when. It just might have been, because some maths things sort of came natural to me in primary school so I sort of like enjoyed that (S350, P2, L11-15).

S350 also referred to his grandfather as someone who had motivated his interest in mathematics:

My grandfather was actually a maths teacher, just remembered, yeah so yeah it is somewhere in my family (S350, P1, L19-23).

Majoring in mathematics was not the solitary plan that attracted S350. He was also thinking of pursuing his first choice of university course and perhaps a becoming a doctor of medicine:

I’m still thinking whether I want to go into a doctorate of medicine course like I was saying and I think my current plan is to major in pure maths (S350, P2, L18-20).

Student S350’s case suggested a strong belief in his self-competency in mathematics, starting from childhood with a belief in his grandfather’s ability in mathematics and his sense of his own natural ability, and continuing with the influence of a passionate secondary school teacher. He saw mathematics as part of his identity as he pursued his second choice of a mathematics major with contentment. That is, as he said, the reason for not being satisfied by doing medicine was that it would not lead him to the major in mathematics.
**Utility value**

Student S350 was heading towards his first interest, medicine, and arranging his subjects according to the prerequisites of this course:

Still do the prerequisite subjects for the doctorate of medicine course, just to keep my options open, so I could go (S350, P2, L20-22).

S350 added that a high pay cheque together with his interest in mathematics were his motives for pursuing a mathematics major course. However his interest came first:

I don’t know, it might be a combination of both [high pay cheque and interest]. It’s never been like a lifelong dream of mine or something but yeah I’m not sure, it’s more something to aim for I guess but it’s still – the subject matter I really enjoy, along with maths I enjoy chemistry and biology subjects as well (S350, P2, L35-39).

S350 also acknowledged being concerned about a high salary, thus expecting monetary benefits from his course, although this didn’t override his enormous interest as revealed in the previous sections.

**Cost value**

Student S350 was not very comfortable talking about his course or major with friends who didn’t show interest in mathematics, which resulted in some cost value:

If my friends at least don’t really mind, like I mean most – if not all of them aren’t very interested in maths but so yeah they don’t, like if I was to talk about some high calculus topic about something they wouldn’t be interested at all but that doesn’t mean that – they still appreciate that I like the subject (S350, P4, L19-23).

Nevertheless, S350 found some friends who appreciated his involvement with mathematics, although this was still coloured by social concepts about mathematics:

When people think of maths they just think of their brain hurting (S350, P4, L55).
In summary, student S350’s high expectation of success that was generated from childhood when he started to learn mathematics until the end of secondary school was now influencing his second choice of course and facilitating his major in mathematics. S350 revealed his interest in mathematics and his plan to utilise his skill in earning a high salary. The intrinsic value of mathematics was fulfilled through joy and interest, and the cost value to him was shaped by friends who were not particularly interested in mathematics, although he encountered some appreciation of the subject as well.

6.3.7 Maths is just something to do with determination and perseverance – S87, S53

Student S87 was invited to take part in the interviews because her first choice, a Bachelor of Engineering, was offered by S53. Her second choice, a Bachelor of Science was still attractive to her. In her survey she said that if her father hadn’t encouraged her to do mathematics, she would have ended up enrolled in humanities. She also had a twin sister who received almost the same support and wanted to be a primary school mathematics or art teacher.

Fear of reducing future job opportunities had led S87 to study engineering instead of mathematics, which was her actual desire.

Expectation of success

Student S87 spoke about her mathematics confidently:

I have one more compulsory maths subject to do next year and I’m looking forward to the maths ’cause it's an extension of the stuff I did last semester (S87, P2, L59-61).

S87 suggested her ability in mathematics was the result of receiving active encouragement from her Year 11 mathematics teacher:

Grade 10 [teacher] was a person who encouraged me to try Maths C ’cause he knew I could do it so he ... he kind of passed on some of his passion for maths (S87, P3, L11-25).
She concluded discussing her experience with a statement about the influence of teaching methods on making learning desirable and enjoyable:

Ability to do it [maths] depends on how people teach you because if it's something that you just rote learn, do over and over and over again, it's not that much fun. But if you have a teacher who is passionate ... people are more likely to continue doing it (S87, P1, L12-17).

Student S87 appeared to talk about her mathematics ability quite differently from students S336, S384, and S326, who saw it as an innate ability. In the above quote she pointed to the impact of external factors, such as quality of teaching, which contrasted with the natural ability discussed by S384 who thought that there is a certain genetic pre-disposition for any sort of ability, or S326 who believed his ability came from his mathematician grandfather.

S87 expressed her belief in external factors influencing individuals’ attitudes towards mathematics when she spoke about her parents’ consistency in helping her solve mathematics problems. For example, she remembered her mother and father helping her and her twin sister with mathematics homework, and that this support made a big difference to her interest and ability in the subject:

Mum and dad would always sit down with us and work through the [maths] problems until we understood it and we could do it by ourselves ... so it was always good to have that support and guidance as well. It made a big difference (S87, P1, L26-31).

In terms of the impact of external factors, S87 suggested that the difference between her social behaviour and that of her twin sister might have been a personal choice that had affected their attitude towards mathematics. Her sister, who had received the same assistance from their parents, was now planning to become a primary school mathematics or art teacher:

I think it might have something to do with our social behaviour. My sister is a lot more social than I am and I'm a lot happier to sit at home with a maths book or watching a documentary or something silly like that. So my sister enjoys going out shopping and chatting with friends a lot more, so it might have something to do with that (S87, P2, L30-34).
Interestingly, the remarks S87 made about the different impact of her parents’ assistance on her twin sister and herself while staying at home, when her sister preferred to be out socialising, was quite different to other students who said they were “naturally” good at mathematics. Student S87 expected to succeed at mathematics because she had been supported and had stayed home with her mathematics books, and not because she had a “mathematical brain”.

**Intrinsic value**

As with several other cases described above (i.e. students S336, S384, and S350), student S87 enjoyed a sense of achievement after doing mathematics tasks and an appreciation of the straightforward outcomes of mathematical problems.

I prefer doing the maths and sciences purely because there's always a yes or no answer. It's a right or wrong. ... I can't be a bit of both, so with maths it's always you've done it right and you always get that sense of achievement when you know you've done it (S87, P1, L35-41).

Student S87 was thinking of getting back to a mathematics science course, and her interest in pure mathematics resulted in a high level of intrinsic value.

**Attainment value**

Student S87 sounded satisfied with her engineering course, as part of her long term tertiary study plan that was based on her mathematics ability, especially when she no longer had to do science and therefore could take a longer path by spending one more year in mathematics:

I kind of figured wherever I'd go I'd get into an engineering course, one way or another, if it was doing a year of science [maths] first and then transferring or straight into engineering. So I was lucky enough to get straight into engineering at [SS3] and I'm very happy to have done so (S87, P3, L40-45).

S87’s personal identity, which had been formed by staying home and enjoying her books as mentioned in the section on expectation of success, matched with the course she was studying as it was “mixed with high level mathematics”.

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Utility value

Student S87 was sure that her course would lead to careers that would not restrict her to something she was not happy with, such as working in a laboratory or working with mathematics equations:

I didn’t want to be stuck in a lab or in a room doing endless equations for days on end and stuff like that so it [engineering] was more being able to apply what I’d learnt (S87, P4, L37-40).

Cost value

Cost value was a factor for S87 when she realised how her passion for mathematics would limit her career opportunities and possibly leave her with a low income. Her decision to do engineering was almost a solution for combining mathematics and money together:

I wanted to do something where I could continue doing maths and science but I wanted to do something with maths and science that I knew was going to earn me a bit of money, because the thing I was scared of with doing a science degree and then majoring in maths or chemistry was that I’d finish my degree but then not really be anything (S87, P4, L20-25).

It appears that in this case the utility value and cost value are interacting because while S87 wanted to study something that would lead to a good paying job, the attraction of mathematics might have limited the range of her choices, so engineering was her compromise – a solution that would allow her to study mathematics and get a job that paid well.

In summary, student S87 explicitly explained the role of environment and external factors on her ability in mathematics, consolidated by her social behaviour of staying home with her books. This was in contrast to other cases that illustrated high intrinsic value with students referring to their ability as being based on nature or genes. The uniqueness of this case was her twin sister’s different attitude toward mathematics, involving different pathways, while they both received the same guidance from their parents. S87’s weighing up of the utility and cost value of
mathematical study in terms of future employability and income was the other exclusive feature of this case.

6.3.8 Maths can seriously be done as a career; it's not just an interest or a hobby – S126, TEC2

Two students, S38 and S126, indicated a strong extrinsic motivation for studying mathematics in their survey responses (see Figure 6.1). However, results of student S38’s interview did not support his survey responses, with extrinsic motivation not featuring as a factor in his description of his decision to study university mathematics. Extrinsic motivation was evident in student S126’s interview and combined with intrinsic enjoyment and an expectation of success to contribute to his high level of motivation to pursue mathematical studies. Student S126 was doing a Bachelor of Mathematics at TEC2. He finished secondary school in 2007 and enrolled in a business course at university after four years working and studying. He did not find the business course interesting and enrolled in a Bachelor in Mathematics because he liked working with numbers at secondary school while he was doing an accounting subject and believed this would be an easy way to get a job. He was encouraged by a family friend who advised him of a wide range of job opportunities after completing a mathematics degree, in contrast with student S87 who saw such job opportunities as limited.

Expectation of success

Student S126 expressed his expectation of success by talking about the number of mathematics subjects in his course:

I've done seven at the moment yeah, so there are 24 in the Bachelor of Mathematics. So there's a fair few to get through. Yeah it's all right. I'll have a lot of time to when the exams are over (S126, P1, L21-25).

S126 showed his passion and determination for doing his mathematics course using his whole ability:

Now that I'm doing the degree that I want to do I am putting a lot of energy into it, like I am quite driven in it. Whereas at school, like you're young it's
quite social as well, so, yeah, I'm much more focused. I'm much more driven now (S126, P5-6, L55-56; L1-2).

While he stopped “socialising” and “put more focus” on his higher education, S126 expected different possibilities with mathematics and was trying to decide about his mathematics specialities:

Even though I'm not – there's still – there's a lot of different possibilities with maths so I'm not too sure what I want to specialise in (S126, P2, L9-11).

Remembering his interest in numbers during schooling made S126 swap from business to mathematical science and demonstrated his expectation of success by specialising in this field.

**Intrinsic value**

Student S126 had experienced some intrinsic motivation towards mathematics in secondary school and then later remembered this interest:

I started to get a bit of a taste for that in high school with really basic algebra and geometry and stuff like that (S126, P3, L17-22).

I just remembered from school, like through accounting how much I loved working with numbers and I did physics and maths at school, so then I realised how much I liked it (S126, P1, L52-54).

As was the case for several other interviewees, S126 liked the right or wrong answers of mathematics in comparison with other subjects, where answers might be interpreted differently by different people:

With maths there is a right and a wrong, I really like that, I like that cut and dried nature of it (L26-27, P:5).

S126 also expressed his joy of doing mathematics:

For me it was very much, I guess, came out of really enjoying maths (S126, P4, L21-22).

He was happy about the subject he was doing, explaining:

I'm doing a course at the moment called discrete mathematics and they use that with cryptography and stuff so I really like that (S126, P3, L17-22).
Later S126 explained his appreciation mathematical modelling:

I really like how you can – you’re able to quantify something in the real world and model it (S126, P3, L17-18).

Student S126’s intrinsic value of using numbers in accountancy, revealed at secondary school, supported him in completing his university course, leading him to a job he hoped to get.

**Attainment value**

Student S126 changed his course and field of study a few times until he was fulfilling his need for personal importance and confirming salient aspects of self through his study of mathematics (Eccles et al, 1998). He was happy about his parents’ role in helping him to make independent decisions in agreement with Eccles’ (2009a) value model and in forming his identity as a member of his society:

> For my generation, when you leave school you want to do this, and you want to do that, and it changes every few months. And I was very much the same way, but I was never pressured into doing anything, like they [parents] encouraged me, but it was never pressure (S126, P4, L17-21).

S126 believed that the sense of order he found in Christianity was part of his motivation towards mathematics and the person that he wanted to be:

> With maths it’s very ordered ... so being able to feel that order and being able to trace things back and go ... gives me a great sense of awe (S126, P3, L37-47).

But S126 admitted that his friend was his actual encouragement:

> I have a friend, who is doing a PhD in physics.... Yeah I really admire him academically, so he was someone who really encouraged ... me into it (S126, P2, L24-26).

Believing in his own ability in mathematics, together with his friend’s encouragement, shaped S126’s sense of the attainment value of mathematics, which was not yet very clear after leaving school.
Utility value

The following quote illustrates the way in which S126’s Bachelor of Mathematics related to his future goals. It appeared that his extrinsic motivation for mathematical study emerged through the utility it provided for a future career path:

It’s actually something that ... you can do as a career, it’s not just like an interest or a hobby (S126, P2, L26-31).

S126 then added that his mathematics course linked the skills he would need for cryptography in a military career:

I’m starting to lean towards that way with things like cryptography and data encryption. Military companies use it, so possibly something in data encryption (S126, P2 L40-42).

Moving from “socialising” after completing secondary school, doing part of a business course, and then adjusting himself to a course with a variety of career options elevated the level of utility value S126 attached to mathematics.

Cost value

In addition to spending a few years trying different courses of study, student S126 incurred further costs by enrolling in his chosen course, which required a greater time commitment. This meant he might lose his part time job in the following semester and consequently not have sufficient financial support:

I have a part time job at the moment but looking on into next semester I don’t think I can sustain it, so it is quite time consuming, yeah. (S126, P4, L32-33).

The cost value incurred in this case was similar to that for several other students (e.g. S47 and S336) who needed to adjust their study time to fit with a part time job.

In summary, student S126 experienced different options and tried a few fields of study and indifferent occupations after graduating from secondary school. He was convinced that completing a mathematics degree would build his future
career. He showed an expectation of success by putting his whole energy into the branch of mathematics that he liked. This branch also stimulated his intrinsic motivation, taking him towards jobs his friends encouraged him to think of, which reflected high utility value. However, he did fear losing his part time job the following semester as his course would take more of his time.

6.3.9 Magic Jackson walked me through the steps – S178, SS3

Student S178, studying mechatronic engineering, belonged to the group that didn’t like mathematics but was doing it as a course requirement. He was chosen for the case study because he loved doing mechatronics engineering, although he did not believe he would find a job in Australia. He had developed an interest in science since Year 10 and did not wish to give it up for any reason. His negative attitude towards mathematics was based on the lack of enthusiasm in the subject by some of his secondary school teachers. He was never happy with mathematics, but had to complete it as a requirement for his favourite university program. He was doing engineering at SS3.

Expectation of success

Student S178 blamed secondary school teachers who did not “grab his attention” for his lack of expectation of success (Bandura, 1997). He saw his minimal engagement with mathematics during school as leading to a low expectation of success at university and the need for remediation:

In high school some of the teachers just didn't quite grab my attention ... instead of trying to do as well as I could I just sort of did as needed [utility value]. And that sort of left me a little bit behind when I got to university maths because I had to go back and go over everything again (S178, P1, L48-54).

Success or failure in mathematics was seen as a reflection of an external source such as quality of teaching:

I was always sort of good at maths and then got through senior high school and I found it depending on – oh it depends on a lot of things, depending on the lecturer I have, how they teach things, depending on whether I can get
S178 then complained of a lack interest in working with a list of questions and a formula that he did not know how to use in solving problems:

But if I'm just shown a whole bunch of equations or just a formula and told to use this then I'm lost. Which is a lot of what the maths is now. So that made things a little bit more difficult for me. So that's the main reason I'm not so fond of the maths (S178, P1, L4-7).

However, a good tutor had developed his interest by explaining and stimulating his intrinsic motivation to do examples and eventually linking S178’s effort to intrinsic value:

But now look over 2000, it all looks really easy. That really helped that our tutor was ... really good. He’d go through the examples and it was explained which is what’s for me (S178, P2, L17-20).

S178 then spoke about his friend who motivated him to do his tasks and understand the context, probably providing the further support he needed, which had been mostly lacking from his teachers or lecturers:

I've always had one friend called Jackson and he's just – we call him Magic Jackson because everything he touches works, regardless of what it is (Laughing). ... And people like him, students who do that sort of thing who don't just give it to you outright; they walk you through the steps. That helps a whole lot, helps in maths and everything else as well (S178, P3, L40-48).

S178’s endeavours in catching up with the compulsory subject after not being satisfied with school mathematics teaching took his expectation of success to a high level in this case.

_Intrinsic value_

The signs of intrinsic value in the section on expectation of success above declined due to the complexity of senior mathematics and not finding the connection between subject matter and solutions because of poor student-teacher communication as expressed in the following:
From probably Year 11 up to University, you then start getting formulas ... the situation so some are hard and that didn't always click as well as it should have. It was just here you go, use it. But why, why would I use that? So that put me off as well I think. (S178, P2, L54-57; P3, L1-2).

The above quote shows that there was an opportunity for intrinsic value and S178 would have probably been more successful if he had encountered teachers and teaching methods that better catered for his needs.

No evidence of attainment value was found in this student’s case.

**Utility value**

Student S178 revealed his problem with mathematics and interest in engineering, which made his need for completing a pre-requisite course more obvious:

It was more that by about grade 10 I sort of knew what I wanted to do. So I wanted to go towards Mechatronics and looking at pre-requisites for Engineering, like okay you have to do Maths B, you can do maths here at high school or you can do this ... at university. And so it was sort of like, oh well I'll just do it now. So that led to my high school course (S178, P3, L9-14).

S178 also hoped to find a profitable job after finishing his course:

So finish degree, get a job, save as much money as possible (S178, P4, L10-16).

**Cost value**

The cost that student S178 might have experienced is his need for assistance in upgrading his mathematics knowledge to university level requirements needed him to get a bit of help:

I've been helped out a bit there and then the huge step up to university level maths was just a stage of complexity, whilst continued to annoy me up until pretty much now. But it's just – It was confusing (S178, P1, L54-56).

The other cost that relates to S178’s course was a limited job market in Australia, which might make him experience problems due to the possible need to relocate and change his country of residence:
There aren’t really many Mechatronics jobs in Australia so I’ll either end up doing, working in either any of the branches in IKEA or ... I could probably look for a job in the UK quite easily and follow that up and get that kind of future (S178, P4, L10-16).

The source of cost value that comes through in the above quotes lies in the academic struggle he has encountered when trying to make sense of the course content, both at school and at university, compounded by anxiety about job scarcity in his field.

In summary, student S178 articulated clearly the type of support that he needed to be successful in mathematics and told a story of a lack of such support at school and in his university course. Attainment value and intrinsic value did not feature strongly; however, his comment about liking “logic”, echoing the comments of previous cases, suggested that there was potential for intrinsic value if the right support was available. His interest towards Mechatronic engineering made him hire tutors and get help, suggesting utility value and cost value when encountering academic challenges, in addition to S178 being concerned about future job market limitations in Australia.

6.3.10 That’s how things happen in India – S145, TEC2

There were three students who were invited to interview because their survey responses suggested they belonged to different ethnic groups: S354, S145, and S264. Student S145 was doing engineering and was selected for the case study because of his strong belief of the role of his Indian ethnicity in his decision to pursue university mathematics. Another reason for choosing S145 was the high number of Indian students among international students in Australia. S145 was doing engineering at TEC2.

Expectation of success

As student S145 was going over his memories of learning mathematics in his home country, he mentioned a lot of pressure from his parents regarding learning mathematics in order for him to gain entry to an engineering course:
We have this entrance examination and you need to prepare for that a lot ... like almost the mathematics that we do in engineering, it almost includes all of it, so there's really that amazing ..., not difficult but it's amazing (S145, P3, L49-54).

Learning mathematics was essential for children as well as being considered a big responsibility for parents:

My dad used to make me recite times tables because we are not allowed calculators in India in schools.... So we need to be really fluent and quick at getting ... multiplication results (S145, P1, L47-55).

In demonstrating high expectation of success during secondary school S145 explained how at secondary school all the students liked mathematics and it was not difficult but was fun (S145, P1, L45-47).

**Intrinsic value**

Eccles (2009a), in developing her arguments about intrinsic value, states that individuals have different desires to learn. S145 explained his reasons for choosing engineering as follows:

The thing is I chose engineering mainly because both of my parents [and grandfather and uncles] are engineers ... so it's like family job ... So everyone I meet, everyone around me happens to be engineer. So they always keep on telling me things ... that fascinated me (S 145, P1, L30-40).

One of the three needs identified by Connell (1997 is the need for relatedness, together with the need for competence and autonomy. This quote reveals both S145’s intrinsic and attainment value, explaining the need for relatedness as he mentioned enjoying listening to his relatives’ conversations about engineering, which fascinated him.

**Attainment value**

Student S145 was obviously clear about his future plans as he really wanted to be like his parents, drawing an image of his self-schema:

I really want to be like my parents. Because it’s something that interests me, they tell me what that job consists of, like designing the control systems and designing and programming and writing (S145, P5, L47-52).
For some, learning is driven by curiosity (Eccles, 2009a). As S145 stated:

Yes I might have enjoyed the subject. It's curiosity that I have about different things, and different ideas that I keep on getting. I always wonder, can this be made better, can this be made this way. Its different ideas that keep on coming to my mind (S145, P4, L31-34)

After explaining about the entrance exam in his country of origin, S145 proudly explained their manual, non-electronic learning methods, and how they had to learn mathematics “properly” to the level that enabled them to pass the engineering entry test:

We don’t use calculators, even in our twelfth grade. We start using calculators from engineering, I mean we use calculators at home (S145, P2, L2-3).

If you want to go for engineering then you have to pass many maths exams (S145, P2, L10-11).

Apart from that, [we] needed learn mathematics properly (S145, P1, L47).

People in India, as S145 said, do not make choices based on interest. Their first preference is determined by social approval and for him this was limited to just two fields:

People do like, generally not doing anything apart from engineering and doctorate [like medicine] if cannot get into it. That’s why they do something else, not because [they] like it. That’s how things happen in India (S145, P1, L42-44).

The fact of having so much pressure to learn mathematics was hidden behind the higher education entrance exams that gave a sign of utility value:

The thing is we have this entrance examination and you need to prepare for that a lot, and you need to focus a lot on your mathematical skills, working with complex numbers … and stuff like that – a lot of it (S145, P2, L53-56).

S145 spoke about national ranking, courses entry, awards and mathematics scholarship, and the way they were pushed to enhance their knowledge hoping to reach the required score:
You need to prepare for it then increase your efficiency, increase your speed ... you needed to work on it really hard (S145, P2, L30-31).

That’s how things happen in India, so that was one of the main reasons for choosing engineering and that involves mathematics as well (S145, P1, L44-45).

The quotes above suggest high attainment value, surrounded by strong cultural values and beliefs. S145’s choice was overshadowed by the influence of his parents and relatives and he was happy to follow them.

There was no evidence of utility value in this case.

Cost value

Student S145 identified the cost of his choice as apparently missing relatives and friends:

My dad applied for a permanent residence in Australia, so we shifted here anyways and I had started my engineering (S145, P4, L1-2).

Like my dad had two brothers. So we used to stay together initially, we used to stay in the same house. So I had cousins, so we used to be together almost all the time. But then he shifted ... here and New Zealand (S145, P6, L13-16).

The cost value for this student is different from that for others who enjoy living at home, not having to deal with migrating to another country. This was not a monetary cost (as was the case for S47), or time (S384) or academic cost (S354).

In summary, student S145 was happy with his course, had a high expectation of success, and showed a high level of interest (intrinsic value). The attainment value he attributed to mathematics also appeared high as he experienced an ongoing challenge in learning mathematics to fulfil the requirements for his engineering course, which had been greatly determined by his cultural background. He was utilising mathematics for this course, but had to endure the cost of missing relatives and friends in his new country.
6.3.11 My dad and my brother both came here – S264, SS1

Student S264 had immense involvement with mathematics and family financial support during her schooling, putting her in the category of a family from a higher SES background compared with two other interviewees (S369 and S294). Her best friend was also is doing engineering with her. She blamed her end of semester (October) heavy workload for being late at the interview and admitted to forgetting her appointments sometimes.

S264’s father has a PhD in chemistry and a good knowledge of mathematics. He has also studied at SS1, many years ago, and had always supported and helped her with her mathematics homework. Her brother was also studying at SS1, doing Engineering in a higher year. S264 had had to decide between her current, preferred “family” university and TEC1 where her brothers’ friends were studying:

The high Asian population at TEC1, like you’ve got to be prepared for it ... you’re either in the Asian half or the white minority [as herself] (S264, P3, L24-26).

S264’s other decision was to select between two courses of interest: psychology and engineering. She was doing Bachelor of Biomedical Engineering and a Bachelor of Advanced Science at SS1, but was not yet sure how these dual degree qualifications would help her find an appropriate career path.

This student’s ongoing financial support from her family enabled her to study at high-ranking schools with small classes, with attentive teachers and extra-curricular programs, and allowed upfront payment of all her university fees.

Expectation of success

Student S264 showed a high expectation of success in her current subjects in terms of achieving good results:

I think, 1001, I got distinction and 1002, I think I got a credit – that’s right – and I’m hoping for, maybe a distinction (S264, P1, L39-40).

In response to the question of whether she found university mathematics difficult, S264 answered:
Not the maths itself. The maths I find in conceptual stuff in engineering that I find difficult, to look at a problem and know how to do it. But if someone says how to do it, then [it is all right] (S264, P5, L11-13).

This exhibits some expectation of success, although not at a high level.

S264 was good at mathematics from primary school, although she found her classwork boring and needed a tutor for extra work:

In primary school I went and got extra tutoring in maths because I was bored at school – it was kind of an extension maths (S264, P2, L12-13).

Extra tutoring at primary school and hoping for distinctions at university are clear indications of high expectation of success, in this case both in terms of herself and her parents.

Intrinsic value

The first element of intrinsic value, enjoyment of task, is linked to intrinsic motivation (Deci & Flaste, 1996) and this appears in student S264’s following acknowledgment of enjoying mathematics as her favourite subject:

I guess I always just enjoyed doing maths and that was my favourite subject always during school (S264, P1, L17 & 20).

Yeah a pretty wide range of subjects; physics and ... maths ... I did music and religion and stuff, but maths is the subject that I enjoyed the most (S264, P1, L26-27).

S264 explained her job priorities after completing her studies, where her interest overcame her desire for a high paid job:

Well I don’t want to be bored in the job I end up doing for the rest of my life, so I guess my interest [involving maths] is more important than being highly paid (S264, P4, L9-10).

Attainment value

Student S264 stated her main reason for choosing university was due to her father and brother’s involvement with the same university and course. The effect of family connections on her choice and the fact that her best friend also attended the
university might have been related to her cultural schema and her conception of social script and proper behaviour, indicating attainment value:

My main reason, I guess, would be for coming here is my dad and my brother both came here and they speak highly of it, and I think that it has a very good reputation ... highly ranked university in the states (S264, P3, L47-49).

S264’s happy school experience, as well as her success in choice of university, strengthened her attainment value:

I loved my school teachers. Yeah, they were really helpful and encouraging, and we had quite small classes, which were really helpful – a big change to university (L23-26, P2).

During her last year at school, S264 added psychology to her higher study plans:

I went to a camp. It was for the new science forum, in January. It was ... Year 12, so it was January 2010, and there were lots of speakers ... half science, like leadership team building ... like psychology ... that really interested me. And so, I’d never considered psychology before (S264, P4, L45-50).

Later S264 decided to do engineering as her second course:

I was going to just do a science degree in maths and psychology, but then I decided to do the engineering, because I’m glad about the engineering because I really like it, but I don’t want to lose psychology either (S264, P3, L3-6).

She explained about her career aspirations after completing a psychology course:

And it’s like with psychology, I don’t want to do like clinical psychology or anything like that, it’d be more a research-based thing (S264, P4, L20-22).

All of the above experiences, from school camps to choice of university course, and her handling of university study in order to widen options, resulted in high attainment value for S264.

**Utility value**

Student S264’s decision to have mathematics as part of her study specialty by utilising it to complete her engineering course was expressed as follows:
Engineering would be more mathematical and if I was to go down the psychology road ... I don’t want to lose all my maths work altogether (S264, P2, L56-57).

This sentence reveals how mathematics was fitted into her plan and fulfilled her psychological needs.

In following quote, S264 showed her concern for continuing both the more mathematical engineering and psychology:

I really like it [engineering], but I don’t want to lose psychology either. But I’m never going to get a job that uses both engineering and psychology, so I’ll have to decide eventually (S264, P3, L5-7).

S264 was well informed regarding the role of mathematics in both her fields, thereby showing signs of utility value in her case.

Cost value

Having access to several courses of interest, meant Student S264 had to face a difficult situation that appeared to her as the need to endure some kind of cost:

Well I have a bit of a problem with it. I have an engineering path, and in my science path I’m leaning towards psychology, and so, engineering and psychology don’t go very well together (S264, P2, L43-45).

She anticipated losing control over future jobs so a cost value is inevitable. She said:

But I’m never going to get a job that uses both engineering and psychology, so I’ll have to decide eventually. (S264, P3, L3-7).

The perception of a low-income career in either of the fields of psychology or engineering was another concern, this time involving monetary instability:

So that would definitely be quite low paid job and particularly female engineer is same (S264, P4, L23-24).

Demonstrating the ability to handle a big study load, S264 needed to make a final decision about her future career, while her anxiety resulted in some cost value.

In summary, student S264’s interview illustrated her high expectation of success, intrinsic, attainment, and utility values. However, the broad range of her university subjects and courses had situated her in a stage of decision-making
where ultimately sacrificing one of her fields of interest may affect her cost value. Her family’s financial support had most likely played a significant role in her choice to study mathematics and, as Eccles (2009a) asserts, cost is important to choice and is linked to social identity formation. Unlike other cases where financial costs featured as a salient part of the students’ stories, it did not feature as a concern here.

### 6.7 Summary of the interview findings

The Eccles framework was used as a theoretical tool when reading the interviews and was used to structure the sub-headings of each case in this chapter. The framework was also used to identify which of the 27 interviewees’ responses could be classified under the different aspects of the Eccles framework.

Numerous features emerged as salient across a number of the eleven case studies presented in this chapter, as well as the data from all 27 interviews. The six most prominent features or themes are: **Attainment value, Expectation of success, Intrinsic value, Non-linear pathways, Quality teaching and Utility value**. The six most prominent features or themes emerged based on judgements made on the importance and influence for each case study, rather than the frequency of occurrence. The six most prominent features are summarised briefly below, with an indication of the cases where they were significant.

**Attainment value**

Attainment value emerged as the strong feature of many (10 of 11) of the stories told in interviews about pathways into university study of mathematics, manifesting as a sense of being a mathematical person, someone with innate mathematics ability (S377, S384), coming from a family tradition of learning mathematics (S336, S178, S264), having a genetic legacy of mathematical ability (S350, S326), or coming from a cultural background that values mathematical achievement (S334, S87, S145).
Expectation of success

A high expectation of success was expressed by most of the interviewees (9 out of 11 cases), sometimes based on previous success at school (S350, S145, S126, S384), a sense of self-efficacy (S336, S264), something that developed gradually over time (S377, S326), or due to external factors (S87). The two exceptions (S47 and S178) told stories of persisting with mathematical studies despite experiencing failure and needing remediation and extra support.

Intrinsic value

Intrinsic value also emerged as a strong feature of many (8 of 11) of the interviewees’ stories, expressed as a valuing of logic, truth, “right or wrong” thinking (S47, S336, S384, S326, S350, S87), and related by some students to other domains such as music (S377), and religion (S126).

Non-linear pathways

A non-traditional pathway into university study of mathematics – dropping subjects, changing courses, and shifting occupations back and forth – was reported by five of the eleven cases (S47, S384, S87, S126, S264).

Quality teaching

All 27 students who were interviewed described an influential role played by a secondary school teacher in their attitudes towards mathematics and their level of engagement with the subject. Some students admired mathematics teachers for providing help (S336, S294, S384), while others criticised them for influencing the negative attitudes they had towards mathematics (S82; S264). Good teacher-student relationships and appropriate teaching methods were frequently remembered by many students, for example, S350 whose study direction and future occupation changed because of a mathematics teacher’s encouragement. However some students complained of the lack of a pleasant relationship with teachers (S379; S117) and explained that they had lost interest at primary school.

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level when their academic preferences and self-concept were in the process of developing (S294; S391).

**Utility value**

Although evident in most cases, utility value featured strongly in only two of the eleven cases (S47, S354), with this type of value seeming to be outweighed by intrinsic and attainment value in most cases, where these other types of value appear to be a primary motivator.

**Other factors**

There are other factors that have been detected in previous research but did not feature as strongly as the factors mentioned above. These include:

- **Low financial status** affecting students’ choice of university course, where enrolling in a desired course was postponed in order to accept grants, work or move home to save money to complete a university course.
- **Influence of peers and friends** also did not surface as strongly as was predicted by the literature.
- **Cost value**, including time constraints because of working during studying and, in just one case, losing family support for pursuing mathematics instead of a traditional profession.

Chapter 7 will integrate the findings from the survey (Chapter 5) and the interviews (this chapter) in order to begin to address the research questions.
CHAPTER 7  DISCUSSION

This chapter addresses the research questions by drawing together the results from the analysis of both the survey and the interview data. It therefore draws on conclusions from Chapters 5 and 6.

For the sake of convenience, the main research question and subsidiary questions are presented again below. The findings are discussed in relation to each of the subsidiary research questions.

7.1  Review of the research questions

The research questions, which were discussed in Chapter 3, are listed again below. The overarching research question was:

RQ  What factors influence students’ decisions to study mathematics at university?

The subsidiary research questions used to help answer this question were:

SQ1  What pathways into the study of courses involving mathematics are reported by undergraduate students?

SQ2  What do undergraduate students of mathematics perceive to be the value of studying mathematics at university?

SQ3  What do undergraduate students of mathematics perceive to be the influence of their school experience on their decisions to study mathematics at university?

SQ4  What do undergraduate students of mathematics perceive to be the influence of their family backgrounds on their decisions to study mathematics at university?
7.2 **Pathways into the study of courses involving mathematics**

The conventional pathway into tertiary study via direct entry following secondary school is now complemented by other alternate pathways that have become common, including taking a gap year, and taking another course of study or employment prior to commencing university (McInnis & James, 1995; Young, 2007; Lumsden & Stanwick, 2012; Martin et al., 2013). The interviews conducted with 27 of the survey respondents gave these students the opportunity to speak in detail about their pathways into the study of mathematics from secondary school to university. The importance of and issues related to alternative pathways were discussed by five of the eleven interview participants who were selected for a case study. Responses regarding pathways are discussed in more detail below.

**Delayed commencement of studies**

The participants perceived that returning to university after a break in their studies made them more interested in their studies than others who did not take such breaks (see §6.2). This has been discussed in previous studies (e.g., Lumsden & Stanwick, 2012). Issues around making the transition to tertiary study were also a consideration for Australian domestic students who needed to negotiate changing home towns or states, which could lead to delays in taking up university studies (see §6.2).

**Changing course of study**

Another alternate pathway into undergraduate mathematics studies was via courses that had been completed or partially completed before changing into the student’s current course. Some students explained in the interviews that they had previously enrolled in a different course – for example, a diploma course or a traineeship – before eventually enrolling in their current course to upgrade their qualifications (e.g., S47, §6.2). Others, after completing their degree, had realised that they did not like the kind of work that was available to them (e.g., S29, §5.2.1; S38, §6.2), so they sought different qualifications. An Australian study (Wright, 2010) found that the mismatch between university course content, future job
aspirations, and students’ needs usually resulted in students changing their future careers and therefore their educational plans. According to this study, students either do not have knowledge about their chosen university field and its ability to meet their educational expectations or are not clear about their real interest.

Previous studies have also reported that sometimes the highest achieving students remain unaware of university courses and their educational opportunities as a result of accepting information about the higher education market published by the media or received from school advisors (Brennan, 2000, as cited in James, 2001; Burton, 1999).

Five percent of students in the survey indicated that they changed their mind and dropped their first choice after university entry results were announced and pursued pathways other than what they had anticipated during late secondary school. As there was no direct question regarding this issue, it is possible that a greater percentage of students had experienced the impetus to change direction but did not report it. Some students pursued other courses because of incentives such as receiving a scholarship in a field other than their first choice and continued their study to take advantage of this to gain a university degree anyway (e.g., S47, §6.2).

**Joining the workforce**

One of the reasons given by interview students for postponing university studies was financial problems, which required students to look for employment in order to save money for their tertiary studies. Three of the eleven students in the case studies reported that financial reasons forced them to gain employment before studying at university (S47; S377; S14, §6.2).

In summary, data from both the survey and the interviews provided insights into the pathways participants took into courses involving mathematics. The survey data provided some indication of students taking alternative pathways, although this issue was not the focus of a direct question. The interview data provided further insights into why and how these pathways were taken.
As will be discussed below, connections can be made between students’ pathways and findings related to the perceived value of studying mathematics, providing some explanation of why some students might persist in their efforts to pursue mathematical studies even if it means an extended, interrupted, or non-traditional educational pathway.

7.3 Students’ perceptions of the value of university mathematics

The second focus of attention relates to the value of studying mathematics at university as perceived by undergraduate students. Eccles (2009a) proposes that students’ perceptions of the value of studying mathematics varies, depending on their different educational or career aspirations and goals. They suggest that adolescent performance and choice of mathematics “are most directly predicted by their expectancies for success on those tasks and the subjective value they attach to success on those tasks” (Wigfield & Eccles, 2002, p. 92). The perception of value is therefore a key determinant in the choice made from different available options (Eccles, Wigfield, & Schiefele, 1998).

Using Wigfield and Eccles’ (2002) lens on value, the findings of this study in relation to perceptions of value are discussed below relating to: consistency with a sense of self (Attainment value); interest in, and enjoyment of, mathematics (Intrinsic value); fulfilling or supporting a desired course or career (Utility value); and financial, time or other personal investments (Cost value). The factors influencing students’ choice of mathematics at university identified in the survey data can be seen through Wigfield and Eccles’ framework, where Enjoyment is interpreted as Intrinsic value, and Mastery and Use in later career are interpreted as Utility value. However, concepts such as Part of course, Learning more, Influence of peers and Parental interest are more difficult to classify. Further, while Prerequisite and Use in later career may appear on the surface to correspond to Utility value, they could equally be consistent with Attainment value if more was known about the respondents’ sense of self – which can be ascertained from the interview case studies.

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In the *Expectancy Value Theory of Motivation*, decisions to make a particular choice or undertake a particular task are a function of both perceived value and expectation of success. The interview data revealed that most interviewees (9 out of 11 case study students) expressed a strong sense of their own abilities in mathematics, telling stories of previous and ongoing success in this subject area, as consistent with a high expectation of success. The two exceptions (S47 and S178) told stories of persisting with mathematical studies despite experiencing failure and needing remediation and extra support. Their stories featured high levels of perceived utility and attainment value, where success in mathematics was a necessary component of a long-term plan, pursuing careers that were of high importance due to, for example, family values.

*Consistency with sense of self – Attainment value*

Although there was no specific item on the survey that inquired about attainment value, the survey data does support the salience of aspects of attainment value through the significant proportion of survey respondents (78%) who indicated having always liked mathematics since their early years of schooling (§5.5.1). Survey data showed 21% of students attributed influence to their parents’ occupation (§5.6.4), while 30% attributed influence to parents’ education (§5.6.3). It is possible, as indicated by the interview data, that these factors contribute to a perception of attainment value.

Attainment value attributed to mathematical study was the most prominent feature of the interview data. In 10 of the 11 case study interviews, stories reflecting attainment value were told about pathways into higher education mathematical study, manifested diversely as a sense of being a mathematical person, someone with innate mathematics ability (S377; S384, § 6.2), coming from a family tradition of learning mathematics (S336; S178; S264, § 6.2), having a genetic legacy of mathematical ability (S10; S9, §6.2), or coming from a cultural background that values mathematical achievement (S334; S87; S145, §6.2). Interviewees’ descriptions of their sense of self in relation to mathematics demonstrated how statements about such things as career aspiration, which can be
mistaken as utility value, can in fact be manifestations of attainment value, where mathematics and a related career are seen as significant features of the student’s identity. Eccles (2005) explains how attainment value can be mixed with utility value in this way. Interview statements that pointed to attainment value were often coupled with expressions of the students’ previous success and confidence in mathematics and were therefore consistent in most cases with a high expectation of success. Stories of students who were inspired from their early years of schooling by a particular career or occupation, such as engineering (S178, §6.2), secondary school mathematics teaching (S142, Table 6.2), or astronomy (S379, Table 6.2), were common, where these student put all their efforts towards their favourite course and made themselves ready to take all required subjects.

**Enjoyment and interest – Intrinsic value**

Both the survey data and the interview data identify intrinsic value as a significant factor in participants’ pursuit of studying mathematics, with 43% of survey respondents nominating enjoyment as one of their reasons for taking university mathematics (§5.2.1) and 60% selecting it from a list of factors (§5.2.2). This suggests that these students’ selection of mathematics at university is perhaps based on their own interests and enjoyment. In the interview analysis, intrinsic value was again identified as a prominent factor.

The case studies revealed that for many students, their intrinsic interest in mathematics was nurtured by high attainment value and by an expectation of success. This was particularly evident where participation and success in university mathematics featured as part of a longer story of a positive relationship with mathematics, where success was expressed as an important part of a student’s self-image or identity. In their interviews, some students elaborated on their admiration for mathematics through comments such as: “the subject has the power to complement logic” (S336, §6.2); “enriches the scientific environment” (S339, §6.2); “satisfies sense of curiosity” (S145, §6.2); “enhances power of decision making” (S377, §6.2); “simply clicks in the head” (S350, §6.2); or “has either a right or a wrong answer” (S47; S326; S87, §6.2). One interviewee (S326, §6.2) compared the
beauty of mathematics to Beethoven’s 9th Symphony. This positive emotion could be encouraged by passionate teachers (S326, §6.2), indicating the relationship between “interest” and “positive emotion” in helping students make their educational decisions, as discussed by researchers such as Burgin (1999), Eccles (2002), and Ryan and Deci (2000). Some interview participants described how mathematical concepts inspired them through secondary school to pursue a field of study that involved mathematics. One student (S350, §6.2) explained about his increasing interest in the concepts of mathematics during his final school years, until finally he changed his study plan at university and enrolled in mathematics as his major. Such stories are consistent with research by Fredricks and Eccles (2002), Frank et al. (2003), and OECD (2006), which found that school experiences influence students’ choices of university courses of study.

**Fulfilling and supporting a desired course or career – Utility value**

Both the survey and the interview data provide evidence of the role of utility value in students’ decisions to pursue studies in mathematics. In the survey, students reported enrolling in mathematics – with or without intrinsic interest – in order to fulfil their current course requirements. Several sources of utility were identified by survey participants, including the role of mathematics as a prerequisite (10%) and the potential for mathematics to support performance in other subjects (10%). Many students, regardless of whether they showed positive (e.g., S75, §5.2.1) or negative (e.g., S158, §5.2.1) attitudes towards mathematics, indicated that they were studying mathematics because it was a prerequisite or part of their course, with 43% of respondents nominating this as one of their reasons for taking university mathematics and 85% selecting it as a factor from a list given.

Compared with the survey findings, the interviews suggested that utility value was not as influential as other factors, such as attainment value and intrinsic value. The interview data did provide some further elaboration on sources of utility value that were gained through the decision to study mathematics. For example, some students were taking mathematics to strengthen other subjects related to their course, hoping to improve their score or to promote their future studies (S38;
S87; S354, §6.3). These students valued mathematics because of its relation to other fields and its use in many careers and professions. This is consistent with other studies (Frank et al., 2003; OECD, 2006; McPhan et al., 2008; Ridd, 2010), which found that students believe mathematics enhances their level of understanding in other disciplines. Interestingly, some students believe it is just important to learn mathematics. They studied mathematics at university because they wanted to learn more – for example, for the sake of mathematical literacy (S65, §5.5.1), its use in inventing new technology (S384, §6.2), or for its power in achieving a deeper understanding of the world (S123, §5.2.4).

Previous studies (e.g., McInnis, Hartley & Anderson, 2000; OECD, 2004; Calkins & Welki, 2006) have identified the effect of students’ awareness of the high market demand and job opportunities for specialised science degree holders. Students who selected to study mathematics at university might have been aware of this or just relied on information received from other people. In contrast, a lack of knowledge about how a mathematics degree can lead to employability prevented some students from majoring in mathematics as discussed in the interviews (S47; S384; S87; S145, §6.2), confirming arguments made by other researchers (e.g., Tytler, 2007; Thomas, 2009). The possibility of a future career attracted 8% of students surveyed for three different reasons – namely, enhancing their chance of employment, finding a highly paid job, and using mathematical knowledge to improve possibilities for a future career (S29; S326, §5.2.1). Some students, who showed very high interest in mathematics, nevertheless enrolled in courses that could take them to their preferred job, instead of courses that heavily involved mathematics. Expressions of the utility value of mathematical studies for future careers is sometimes difficult to distinguish from attainment value because career aspirations are often as much an expression of a sense of self and identity as they are of the utility value that is accrued by gaining employment and having a career.
Financial, time, and other personal investment – Cost value

Both the interview and survey data can be used to support the argument that students are aware of the costs attached to studying mathematics at university. These include financial costs, time costs, and other personal costs related to stereotypes associated with success in mathematics. The fact that many students work to pay higher education expenses has been noted in many earlier studies (Zimmer-Gembeck & Mortimer, 2006; Mortimer, Vuolo, Staff, Wakefield, & Xie, 2007; Van Horn, Zukin, Szeltner, & Stone, 2012). It has been claimed by students in earlier research (e.g., Chinnappan et al., 2007; McPhan et al., 2008) that studying mathematics for students who do not find the subject easy means they need more time to complete tasks and that this came at the cost of struggling with time allocation for their personal schedules. The survey revealed that a small number of students perceived mathematics as needing more time to learn than other subject areas, so they did not plan to study mathematics subjects at the same time as working.

The cost of studying mathematics that students endure is mostly financial, resulting from losing the part-time jobs that they usually have during study at university. However it also places time restrictions on other activities, with students needing more time for mathematical tasks, as expressed by a number of students in the survey (S87, §5.3.2) and the interviews (S47; S5; S379; S21, §6.2).

While the survey did not ask a direct question about the costs involved in pursuing mathematical studies, the survey data does contain information about sources of discouragement, which was acknowledged by a quarter of the students, of whom almost a third named teachers, and peers and friends, while fewer than 10% named each of parents, everyone, and advisors. Discouragement from studying mathematics is linked to cost value because of the perceived or real consequences of making decisions that are unpopular with significant others. This aspect of cost value was evident in case study interviews where participants described the negative consequences of, for example, going against parents’ wishes, or of being viewed negatively by peers. In interviews, students also talked about their difficulties in structuring a social life and making normal friendships (S384; S350,
§6.2) as a result of studying maths. One student recalled that friends who were not interested in mathematics were not interested in listening to stories about study experiences or sharing their lecture adventures and gave him potentially derogatory names such as “nerd”. However, these kinds of attitudes were not necessarily cast in negative terms and were instead relayed by this particular student in a positive way as part of the interviewee’s self-identity. Although a feature of some interview participants’ stories, cost value did not emerge as strongly influential across the interview data and perceived cost value was outweighed in these stories by the perceived value of persisting with mathematics.

In summary, data collected from participants in both the survey and interviews suggested that each of the types of values discussed in the Wigfield and Eccles model contributed to students’ considerations when deciding to studying mathematics at university. The interview data also suggested that expectation of success was a significant factor, with nearly all of the case study students expressing high expectations of success, while those who did not referred to the additional costs incurred through their past experience of failure, and additional tuition costs and time commitment. In terms of perceptions of value, the survey and interview data suggested different degrees of influence for the four sources of value. For example, attainment value – often coupled with a high expectation of success – emerged in the stories told by 10 of the 11 case study interviewees, while for the survey data utility value (*Part of course*) and intrinsic value (*Enjoyment*) were the two factors most frequently selected and nominated as most influential in students’ choice of mathematics. The qualitative data provided further insights into the survey data, suggesting an intimate relationship between intrinsic value (enjoying and admiring mathematics), attainment value (having mathematical study, achievement and ability as part of one’s identity or sense of self) and also the utility of mathematical study in terms of usefulness in progressing career aspirations consistent with such identities. The detailed stories provided in interviews about individual students’ decision-making and pathways into undergraduate mathematical studies help to illuminate the survey data, including its limitations. However the small number of interviewees and the possible bias introduced by
these students being those who consented to being interviewed suggests the need for a degree of caution in interpreting these results.

In the survey, participants indicated the strong influence of *Enjoyment* related to the intrinsic value of choosing mathematics at university. This was evident in several different types of questions. Utility value was the other strong feature of the survey data that emerged through a high response rate to the factor *Part of course*, motivating students to use mathematics for completing their university course or considering it for *Use in later career*, which appeared as another factor. Analysis of the interview transcripts reveals that these sources of utility value can also indicate attainment value, where aspirations to complete a particular course or pursue a particular career emerge as relevant to students’ sense of self that sometimes reflect family values and traditions. The interview data also suggests that attainment value can support other types of value (e.g., intrinsic value). A long standing interest in mathematics from school to university – together with aspirations for success and a belief in their ability to achieve success – was evident in almost all student stories told in the interviews.

The findings of this study differ from and extend findings of previous studies, where variables such as influences of parental interest, secondary school results, and future high salaries have been identified as influential (e.g., Marks et al., 2001; Meng, 2005; Meldrum, 2006). Factors such as parental interest can be recast as secondary factors that contribute to a sense of self and the amount of attainment value that students might accrue through their pursuit of university mathematics. While previous studies have focused on the direct influence of parents in educational decision-making, this study emphasises the long-term, indirect effects of family commitments and traditions, in particular, subject areas and career destinations. The relationship between career utility and attainment value suggests that caution should be taken when interpreting the meaning and significance of students’ statements about the utilitarian nature of mathematics.
7.4 The impact of school experience

Data from both the survey and interviews suggests that school experience impacts on students’ decisions in choosing mathematics at university. Success at school mathematics is a requirement for some university courses that contain mathematics, and students usually continue studying subjects they have put more effort into and in which they have achieved more success during schooling (Ryan & Watson, 2009). In the first survey question 16% of survey participants (§5.2.1) nominated their mathematics experiences as having influenced their choice of mathematics at university, while 14% of students nominated the fact that they did well at school mathematics as a factor. In a multiple-choice question asking students to select factors that influenced their choice of mathematics, 61% of students’ selected the factor Did well at school (§5.2.2). The difference between percentages is the result of the type of question students were initially asked – that is, in the first of these questions they were asked to use their own words, but in later questions they had to choose from a list of answers by ticking a box. As a result, in the earlier open response question the factors Mathematics experience and Did well at school were not given as the main reason students chose mathematics at university, although in the later closed questions this factor was prominent.

In comparison 16% of survey respondents reported being encouraged and 11% discouraged by primary teachers. Also 63% said a secondary school teacher had encouraged them but 23% reported being discouraged by secondary teachers. In the survey, some students reported that they did not find their primary school experiences encouraging (e.g., S24, §5.4.2), while the interview data suggests that students’ memories and experiences regarding their involvement with mathematics sometimes goes back to their early childhood and continued into secondary school (Chapter 6, §6.2). Passionate, knowledgeable, responsible and approachable secondary school teachers were admired by 63% of survey respondents who related their maths enthusiasm to these kinds of encouraging secondary school teachers (e.g., S328, §5.4.1). Furthermore, several survey respondents (e.g., S51; §5.3.2; S83, §5.5.2) referred to teachers who did not provide quality teaching when explaining
their concerns about mathematics. Some of them blamed their secondary school mathematics teachers for destroying their interest in mathematics that, up until then, had been encouraged in primary school and through home or school support (S379, §5.4.2). Some said teachers made mathematics a difficult subject, although it is not really hard (S5, §5.5.2). In the survey, having a good teacher at secondary school and a comfortable class environment were identified as important contributors to liking mathematics (e.g., S3, 5.5.2).

All 27 students who were interviewed identified the influential role played by a secondary school teacher in their attitudes towards mathematics and their level of engagement with the subject. This finding supports other research that suggests that secondary school experiences are a significant influence of on students’ future mathematical learning (Piotrowski & Hemasinha, 2001; Borman, Hanson, & Tyson, 2004; Mapolelo, 2009). Some students admired mathematics teachers for providing tremendous help at times when they were struggling (S336; S294; 384, §6.2), while others criticised them for influencing the negative attitudes they had towards mathematics and their lack of interest in doing better in the area (S82; S264, §6.2). Good teacher-student relationships and appropriate teaching methods were frequently remembered by many students, for example, S350 (§6.2) whose study direction and future occupation changed because of a mathematics teacher’s encouragement.

In contrast some students who were interviewed complained of the lack of a pleasant relationship with teachers (S379; S117, §6.2) and explained how they had lost interest at primary school level when their academic preferences and self-concept were in the process of developing (S294; S391, §6.2). The early influence of a student’s self-concept on future academic choices has been noted by other researchers (e.g., Khoo & Ainley, 2005; Marks et al., 2001).

Both groups of students, those who discussed positive, and those who discussed negative school influences on their decisions to study mathematics at university in the survey and interviews thought that their secondary school teachers, especially during later periods, had a great effect on their decisions (e.g., S83 §5.5.2). Interview data also demonstrated how school experience interacts with
the different value types. For example, a teacher who is passionate about mathematics might boost students’ sense of the intrinsic value of studying it, or a teacher who affirms a student’s interest or skill in mathematics might contribute to that student’s self-image as a mathematical person and their sense of attainment through the study of mathematics. Teachers also might motivate students to think about the use of mathematics in other subjects thereby playing a part in its utility value or inspiring them to understand the necessity of sacrificing time or money for the sake of something worthwhile. By raising students’ awareness of the value of studying mathematics, these types of messages can counter perceptions of cost involved in choosing mathematics.

In summary, interviewees’ perceptions of school experiences on their decisions to study mathematics at university were often based on the teacher-student relationship. Teachers were believed to either nurture or inhibit students’ enthusiasm in primary or secondary school. Students also mentioned the influence of their peers and friends on their attitudes and decisions in undertaking mathematics at secondary school, or not. Evidently in some cases a student’s interest established at primary school was overshadowed by the quality of teaching by unenthusiastic secondary school teachers. Most students acknowledged that a good relationship with their teachers and a comfortable class environment strengthened their interest and enthusiasm, which helped them make the decision to continue mathematics at university (e.g., S83, §5.5.2; S336, §6.2).

### 7.5 The effect of family background

Analysis of both the survey and the interview data suggests that some students’ choice of a university course involving mathematics were affected by their family’s culture, education, careers or professions, and financial status. Findings in relation to each of these features of family background are discussed below.
Influence of family culture

Survey data revealed that 82% of students did not consider themselves as belonging to a particular cultural group while the remaining 18% identified with 12 different cultural groups (§5.6.1). Among students who considered themselves to be part of a particular cultural group, 25% — that is, 5% of students who participated in the survey — said their ethnic identity affected their choice of university course. Cultural groups indicated by survey respondents comprised: African, Asian, Australian, European, Indian, Middle Eastern, and Religious (§5.6.2). The effect of culture on students’ university course choice is supported by the existing literature (Marks et al., 2001; Anderson, 2005).

In an open response question inquiring into the nature of this influence, students explained how in some countries (e.g., Vietnam) parents encourage children to study courses that are regarded as honourable and supposedly provide a high income — such as medicine, pharmacy, dentistry or law — and prevent them from pursuing other courses such as music, drama or art (S188, §5.6.2).

Data collected from the interviews indicated the impact of family traditions — for example, parents who sat with twin children for all their mathematic homework and assignments (S87, §6.2) — and the impact of homeland culture — e.g., India, where engineering was described as the ultimate goal for a student who was destined to follow in his family profession (S19, §6.2).

The influence of family culture detected in the survey data and supported by interviews had the power to encourage students towards particular courses and careers that might accrue particular types of value — for example, attainment value — when the choice of course and career is linked to a perception of status; or cost value, when the choice of course and career is linked to pressure not to pursue other intrinsically desired pursuits, as was revealed through some case studies (S377; S47; S145, §6.2).

Family education

In addition to the effect of family culture on students’ choice of university course, both the survey and the interview data suggested that factors such as
Parents' career or profession

Family career or profession

Parents' careers are considered to be influential factors on students' course choice by some researchers (Marks et al., 2001; Rochat & Demuynck, 2001; Simpkins, Davis-Kean, & Eccles, 2006; Williams, Pampaka, Black, Hernandez-Martinez, & Wake, 2007). Another influential factor is the level of education and the field of study. A little over a quarter of survey participants acknowledged the influence of family over their choice of university course (e.g., £5, £6, £2). Conversely, a parent's dislike of some fields of study influenced some students who then avoided entering a particular course at university (e.g., £5, £7, £6, £2). These types of parental influences have been noted by other researchers (Evans, 1999; Dawson, 2007; Pearce & Lin, 2007). Some interviewees also recognised the effect of their parents' education on their choice of university course. Some parents, plus 9% siblings (S1, S2, S3), have been encouraged to study mathematics by their family members (8%). These participants acknowledged the influence of family over their choice of university course (e.g., £5, £6, £2). The influence of parental education and family background is evident in students' decision-making process.
study measuring students’ career aspirations (Bandura, Barbaranelli, Capara, & Pastorelli, 2001) also showed students’ choice of university course was indirectly linked to parents’ academic achievements and career aspirations. However, Dustmann (2004) found that a similar parental career background may lead to divergent effects on students’ achievement and academic choice.

The influence of parents’ occupations was identified by 21% survey participants (75 students), many of whom asserted that their parents’ mathematics and science related jobs had affected their choice (e.g., S27; S113, §5.6.4); while some were influenced by other occupations than their parents’ or wanted to do something different to what their parents did (e.g., S357; S66, §5.6.4); and a small number were influenced by the effect of parents’ income (e.g., S61; §5.6.4). Students’ claims of the influence of parents’ occupations on their choice of university course was mentioned in interviews, for example, S47 (§6.2) asserted that “parents instill” their own interests or area of expertise in their children. Even S377 (§6.2), whose mother was a mathematics teacher who did not want her daughter to do mathematics, was first inspired by her mother’s text books.

In interviews, participants’ accounts of the ways in which their parents’ careers influenced their decisions to study mathematics at university were linked by some to their sense of self (attainment value), while others gave more utilitarian explanations, such as pursuing a pathway that was familiar to them because of their parents’ experiences (e.g., S27, §6.2). These students claimed that they knew what they wanted to be because they were inspired by their parents’ careers, and in a few cases students learnt about the applicability of mathematics to particular careers because of familiarity with their parents’ jobs (e.g., S265, §5.6.3). Students’ accounts also suggested that some tolerated significant costs in pursuit of their parents’ profession in order to achieve a desired future lifestyle (S145, §6.2).

**Family financial status**

Both survey and interview data suggest that a family’s financial status played a role in some respondents’ decision to study mathematics at university, with similar findings to previous studies (Ma, 2001, 2009; Lowell & Salzman, 2007; Watt,
Richardson, & Pietsch, 2007, McConney & Perry, 2010). In the survey, students indicated their family’s financial status as either well off (24%), comfortable (62%) or struggling (14%). Twenty-two percent of survey respondents indicated that their family’s financial status influenced their course selection.

Low family financial status was mentioned by some survey participants as influencing them to choose university courses that led to highly paid careers (e.g., S385, §5.6.5). Others had to drop their university course before completion because of financial difficulties (e.g., S313, §5.6.5), but financial limitations prompted some students to become high achievers in order to be better off later (S359, §5.6.8). Some students experienced pressure to complete their studies quickly because of financial difficulties while studying (S215, §5.6.5), and others hoped to get a scholarship that would enable them to complete their study (S83, §5.6.5).

Some interview respondents told stories of working before commencing their university course because of a lack financial support (e.g., S377 §6.2). Some even completed another course to work, save, and then do a course that involved mathematics (S47 §6.2). These types of stories suggest the ways in which the financial cost of university study, including living costs and the opportunity cost of not working, feature in some students’ course selection. Another common outcome of low family socio-economic status was the need to undertake paid employment while studying, or to defer studies in order to save money before commencing a university course. These considerations compete with other value considerations such as the intrinsic value that a student might accrue through the pursuit of mathematical studies.

**Family support and encouragement**

Although data from the survey suggests that parental interest is not a significant factor, the interview data suggested that family support and encouragement play important roles in students’ decisions to study mathematics at university, concurring with existing literature in the area (OECD, 2003; Lyon, 2004; Davis-Kean, 2005; Hannula et al. 2007; McPhan et al., 2008; Ma, 2009; Tytler et al., 2008; Panizzon, 2009). Over half of the students who reported enjoying
mathematics in the interviews also reported benefiting from the support of a family member during schooling (§6.2).

The influence of family support was discussed by 18 of the 27 students interviewed, showing the importance and prevalence of this factor (e.g., S384; S87, §6.2). Parents’ encouragement was discussed by many students in the interviews as the first motive for thinking about what they wanted to learn and what career they wanted to pursue in future life. For many this manifested as the first step in establishing attainment value from studying mathematics at university (e.g., S126; S336; S87; S264, §6.2). Some students claimed that their love of mathematics was instilled in them by their parents (S336, Table 6.2). For some students, grandparents were influential and inspired them to become mathematicians (S326; S364; S377; S350, §6.2). Again, this influence contributed to the sense of attainment gained through mathematical studies, where the students admired those who practised mathematics, aspired to be like these people, and saw themselves as mathematically minded, which was sometimes presented as an inherited family trait (S326, §6.2). For some, their parents’ expectations that they study mathematics meant that they enrolled in their current course instead of pursuing other, more preferred, fields of study (S87, §6.2).

However, some students who did not have a person interested in mathematics in their family and who received no encouragement from home did not show affection towards the subject and wanted to do it only for the sake of completing their courses (S178 §6.2). One of the interview participants (S377, §6.2) mentioned her parents’ negative influence on her pursuit of studying mathematics and found the attitude very discouraging. She started to learn mathematics from her mathematics teacher mother’s text books from an early age when she couldn’t pursue her study of mathematics as it was against parents’ wish that she follow her family’s tradition by becoming physician. She then endured costs associated with leaving home at the age of 15 and working in various jobs until she had saved enough money to commence her university course majoring in mathematics as a mature age student, driven by its intrinsic value. This example is particularly inspiring as it speaks for the significance of intrinsic value driving a student to
endure personal costs associated with going against her parents' wishes and proceeding without parental support. Wigfield, Tonk, and Eccles (2004) explain that the interaction between family background and sources of attainment value plays a central role in the formation of students’ identities and personal aspirations. This is supported by the findings of this study.

In summary, some undergraduate students of mathematics perceived family background as a stimulus on their choice of mathematics at university. Qualitative findings from the interviews elaborate on these findings through detailed stories that participants offered about their decisions and pathways into their current courses. In particular, the interview data points to the important role that family background plays in supporting the attainment value perceived in relation to studying mathematics, as students associate their studies with fulfilling family traditions and aspirations, consistent with ideas cultivated by families since early childhood. The analysis suggests that family support and encouragement, together with family education, are influential factors in students’ decisions to study university mathematics.

As mentioned above and as shown by the survey data, the impact of family support, parents’ levels of education, and parents’ careers and occupations might have contributed to students’ sense of self and attainment value, which featured prominently in the interview case studies. Although the influence of socio-economic background was less commonly reported by participants, it was found to have considerable effect on some students, particularly in terms of the freedom to choose a specific university course without consideration of financial costs, while other students explained how financial hardship restricted their choice. Financial support is often understood as a function of both parents’ level of education and their careers and occupations. In some cases where family encouragement was not provided and financial support was not available, perceived intrinsic value was a determining factor with students persisting in their aspiration to study mathematics despite barriers.
7.3 **Summary**

This chapter has discussed the findings from the analysis of both the survey and the interview data in relation to the four subsidiary research questions. It highlights the complexity of the interactions between students’ educational pathways, perceptions of value, school experiences and family backgrounds on their decisions to pursue mathematical studies at university.

Participants of this study chose different pathways after completing secondary school. Most of them took a conventional pathway and continued to study in higher education institutions directly from secondary school, while some took a gap year, and others joined the work force. Students who joined the work force either saved money for commencing undergraduate courses or did not like their occupation and came back to study to get appropriate qualification in order to change careers.

The value students perceived in pursuing university mathematics included intrinsic value, indicated strongly by the nomination of the factor *Enjoyment* and by the stories told in interview; utility value, which featured strongly in the factor *Part of course* and also sometimes in *Use in later career*; attainment value, which emerged strongly as a salient feature in the interview data, reflecting students’ self-schemas and passion towards mathematics and associated occupations; and cost value, which although not identified as a highly influential factor, was recognised by students in relation to psychological, time and particularly financial costs.

Students’ perceptions of the influence of their school experiences on making decisions to undertake mathematics at university was often related to teacher-student relationship. Students believed that teachers either nurtured or inhibited their enthusiasm in primary or secondary school. A few students also mentioned the influence of their peers and friends on their attitudes and decisions in undertaking mathematics at secondary school. In some cases a student’s interest that was established at primary school was overturned by unenthusiastic secondary school teachers. Many interviewees reported that good relationships with teachers and having classes with a comfortable environment reinforced their interest and
enthusiasm, which in the end helped them to decide to continue studying mathematics at university.

Family background was perceived as influential on decisions to study mathematics at university. This factor played a supporting role in attainment value, where students associated their studies with continuing or satisfying family traditions and aspirations, and as reflecting ideas cultivated by their families since early childhood. The impact of family support, parental education and career that featured prominently in the interview case studies might have played a part in students’ sense of self and attainment value (Wigfield, Tonks, & Eccles, 2004), and had a central role in formation of students’ identities and personal aspirations.

The next chapter summarises the main findings of the research, highlights the limitations of this study, and provides suggestions for further study in the area.
CHAPTER 8  CONCLUSION

Issues behind students’ lack of enthusiasm for taking mathematics at university, the main motivation for this work, have been identified by Australian researchers (e.g., Hall, 2003; Barrington, 2006, 2012;Forgasz, 2004; Cairns, 2007; Chinnappan et al., 2008; Rubinstein, 2009) and those who have examined the effect of the problem on industries (e.g., James, Baldwin & McInnis, 1999; Marks et al., 2001; Hall, 2002; OECD Report, 2004; Thomson et al., 2014).

While there has been extensive research into the reasons why students are reluctant to choose tertiary mathematics, there has been considerably less research into looking at the reasons why some students are interested in and passionate about undertaking tertiary mathematics. This study turns the focus onto the motivation of students who take mathematics at tertiary level, instead of looking at the causes that prevent them pursuing this subject in their undergraduate studies. This is in contrast to previous research that has highlighted impediments to students continuing mathematics at secondary school (e.g., Gootenboer, 2007; Tytler, 2007; McPhan et al., 2008; Wu, 2009; Olatunde, 2010).

This chapter gives a brief overview of the study, discusses its findings in terms of their contributions to the existing research literature, identifies limitations of the study, highlights some of the implications arising from the study, and identifies possible areas for future research.

8.1 Overview of the study

Informed by existing research literature on course selection and mathematics education, this study looked for factors influencing students’ choice of mathematics at university by considering the following aspects:

- pathways into the study of mathematics as reported by current mathematics undergraduates;
• current undergraduate mathematics students’ perceptions of the value of studying mathematics at university, where value is defined by the Eccles framework (Eccles & Wigfield, 1995, 2002);

• undergraduate mathematics students’ perceptions of the influence of their school experience on their decisions to study mathematics at university; and

• undergraduate mathematics students’ perceptions of the influence of their family backgrounds on their decisions to study mathematics.

This study considered the opinions of students currently undertaking first year tertiary mathematics at six Australian universities through a large-scale survey and an interview with selected students to understand the reasons behind their choice of mathematics at university.

Participants who consented to be part of the survey were enrolled in a variety of university courses and had different levels of mathematical background. While over three quarters of the survey participants were undertaking courses requiring mathematics (e.g., Science, Engineering), others were undertaking courses that did not require mathematics but offered the subject as an elective. Approximately 40% of the survey participants were only taking compulsory mathematics, almost a quarter were planning to do a major in mathematics, and the remainder were undertaking some elective mathematics, including possibly a minor in mathematics. Survey data were analysed using descriptive and inferential statistics, with results of this analysis reported in Chapter 5.

In order to gain deeper insights into the reasons for students’ choices, further data were gathered by interviewing 27 students, selected on the basis of their answers to the survey. The selection process is discussed in detail in Chapter 6. The Expectancy Value Theory of Motivation (Eccles & Wigfield, 1995, 2002) was found to be a useful lens for analysing the qualitative data. As a result, influential factors evident in the interview data were organized and discussed using the components of the Eccles framework. This model explains individuals’ achievement-related choices as a function of both their expectations for success (“I can do”) and the value they expect to attain (“I want to do it because ...”). Value is connected to a range of options and to individuals’ goals and aspirations (Eccles et al., 1998). The
Eccles framework incorporates and refines previous theories of motivation, such as distinction between intrinsic and extrinsic motivation, the role of self-efficacy, and the influence of cultural values. As well as expectation of success, Eccles and colleagues established four constructs related to value: intrinsic value, which is the value accrued through enjoyment and intrinsic interest; attainment value, which is the value arising from consistently pursuing a task consistent with one’s self-image; utility value, which is the external reward attained by completing a task in pursuit of a particular goal; and cost value, which includes the consideration of the range of costs incurred by engaging in a task or activity (Eccles, 2009a). The theory explains engagement in voluntary behaviour as requiring an individual to perceive both some degree of expectation of success and one or more of the types of value in such engagement. This framework is explained in detail in Chapter 2.

8.2 Findings

In broad terms, the study found some students to have chosen mathematics enthusiastically and voluntarily, while others had chosen mathematics reluctantly, only because it was part of their course, with many factors influencing their choice.

Students reported having taken a variety of pathways to study university courses that involved mathematics. Some continued their study of mathematics immediately after leaving school; others completed another degree, experienced employment or delayed university entry for one or more years before commencing a university course. This is consistent with previous research (e.g., McInnis & James, 1995; Young, 2007; Lumsden & Stanwick, 2012; Martin et al., 2013). Pathways were not addressed in the survey, but the processes of transition from school to university were described in detail by participants in the interview. Analysis of the interview data found some students who came back to study after completing a different course had either experienced difficulty in finding employment relevant to their first degree or did not feel satisfied with the kind of employment their degree offered. These students hoped a course involving mathematics would improve their career options. Some students who had joined the work force after completing secondary school did so to save money for university, which in some cases meant
saving money to relocate from a small town to a large city. Others, after a period of post-school employment, had returned to study to improve their employment options and standard of living through obtaining a university qualification. These findings are consistent with existing literature on the increasing diversity of educational pathways and the rise of non-traditional pathways (Lumsden & Stanwick, 2012; Martin et al., 2013). Through the interviewees’ narration of these pathways, stories were told that were characterized by high levels of persistence and determination in the face of significant barriers – both financial and other personal or circumstantial barriers.

Evidence of students’ perceptions of the value of studying mathematics was found in both the survey and the interview data, and discussed with reference to the Eccles framework. Intrinsic value featured strongly in both the survey and interview data. In the survey, Enjoyment was reported as the most significant factor by over a quarter of all students (28%), with analysis revealing that this was particularly the case for students enrolled in a Bachelor of Mathematics (58%), for whom mathematics was the core focus of their course. In the interviews, intrinsic value emerged as a salient theme that came out strongly in eight of the eleven case studies, with interviewees describing their appreciation and enjoyment of mathematical knowledge and study. The influence of perceived intrinsic value on students’ course choice is consistent with previous research (e.g., OECD, 2004; Tonka & Eccles, 2004; Calkins & Welki, 2006; Panizzon, & Westwell, 2009).

Attainment value featured strongly in the interview data, and was the type of value identified by the largest number of case study students (10 out of 11) who described mathematical study as closely aligned with their identities. These students described themselves as being “mathematical people”, having innate mathematics ability, or coming from a family tradition of mathematics learning. In the interview data, attainment value was closely associated with intrinsic value. However, attainment value did not feature strongly in the survey responses, nor did other factors often associated with attainment value such as family interest and peer interest. However, many of the written comments made by students in response to the survey items combine aspects of intrinsic value, expectation of
success and attainment, and it is possible that brief statements about the utility of mathematics for career goals also relate to self-concept and long-held plans to pursue a career that is aligned with students’ sense of who they are.

Utility value featured strongly in the survey data. In fact, Part of course was one of two factors most frequently mentioned in the survey (the other being Enjoyment). However, as discussed earlier, it was not always clear whether this factor pointed to purely utilitarian purposes and short-term goals, or whether it was also linked to long-held aspirations (for example, to a particular career) and was therefore associated with attainment value. Numerous forms of utility were associated with studying mathematics, including the fulfilment of course requirements, improving performance in other subject areas, and enhancing employability. Interestingly, Use in later career was only nominated by 9% of survey respondents. This is in a broader social context where there is a high demand for STEM-related graduates in areas such as engineering, information, mechanical and industrial technology, and this employment market has been thought to motivate students to choose mathematics to complete these types of courses (Department of Education, Training and Arts, 2007). Students’ inadequate knowledge regarding careers related to mathematics qualifications might be one of the contextual factors that contribute to Use in later career being a less cited motivation for studying mathematics. In fact, the interview data revealed that some students fear that career opportunities might be limited for those students graduating with degrees focused on mathematics only (e.g., with a mathematics major), leading them to enrol instead in courses that involved some mathematics combined with other discipline areas. This sort of thinking points to the influence of cost value, where the pursuit of mathematics can be conceived in terms of negative consequences or costs. The impact of inadequate career knowledge in this case is consistent with research by James (2002b; 2007) and Khoo and Ainley (2005), who reported that a lack of information regarding the market for mathematics degrees was influential in students’ decision making.

The two different data sets – survey and interview responses – facilitated a deeper understanding of undergraduate mathematics students’ perceptions of the
value of studying mathematics at university than would have been possible from
the interpretation of the survey data alone. For example, the survey responses that
point to Part of course, Use in later career and Mastery in subject as influential
factors, can on the surface appear to relate to utility value, but they could equally
be consistent with attainment value, as was demonstrated for some students when
more about their sense of self was revealed in interview. This observation questions
whether previous studies that interpreted quantifiable survey data as indicating the
strong influence of perceived utility value overstated the role played by this factor
and underplayed the role played by attainment value, which is arguably more
difficult to identify without extended qualitative data. Eccles (2009b) conceptualises
attainment value in terms of “an individual’s identity” (Eccles, 2009b, p. 83), so that
a career aspiration might be consistent with an individual’s self-concept as
developed over a long period of time. So an explanation of choice of course that
refers to a future occupation may be a function of perceived attainment value (e.g.,
“I’ve always wanted to be an engineer”; “my father and uncle are engineers and
that’s the sort of person I am”), rather than a solely utilitarian decision (e.g., “I need
to do mathematics so I can get a job as an engineer”).

The influence of students’ experience of secondary school mathematics on
choice of university course was evident in the survey data where students’ chosen
course was either connected to mathematics strongly (e.g., engineering) or in a
sustained and focused way (e.g., majoring in mathematics). For other courses
where mathematics is positioned as a service subject (e.g., a business degree),
students were less likely to point to their secondary school experience of
mathematics as an influential factor. Previous research (Bandura et al., 2001) has
found that students’ confidence and perceived self-efficacy in secondary school
subjects, including mathematics, is the main determinant of their career aspirations
and life career choice, rather than their academic achievement. The findings of this
study are consistent with previous research suggesting that selecting advanced
mathematics needs high self-efficacy and expectation of success (Pajares & Miller,
1995; McPhan et al., 2008; Tang et al., 2008). The interview data in this study is
consistent with findings from previous studies in that high levels of self-efficacy in
mathematics and a history of success in school mathematics were often expressed in terms of perceived attainment value (“I’m a mathematical person. I’ve always been good at maths”).

Another factor in students’ perception of school mathematics related to teachers’ positive or negative effect on students’ approaches towards learning mathematics. Some survey participants and interviewees put a strong emphasis on their teachers’ impact on their mathematics education from primary to the end of secondary school, which is consistent with existing research (e.g., OECD, 2003; Davis-Kean, 2005; Hannula et al., 2007; Ma, 2009). Five of the eleven case study interviewees identified quality teaching, specifically the significant role played by particular individual teachers, as supporting their mathematics success.

Students’ perceptions of the influence of family backgrounds on their decisions to study mathematics at university may be evident in three different aspects: cultural background and ethnicity, parents’ education, and parents’ financial status. The influence of ethnicity was first noted in the results of the survey and then supported by the interviews, and is consistent with the findings of Hobart et al. (2006), whose study found that some ethnic groups discourage their children from studying humanities and arts subjects, instead encouraging them to enrol courses with high income and social status, such as engineering. This influence of family background has both utility and attainment elements, where course and career selection is associated with both financial means and social status. The impact of ethnicity in subject choice has previously been identified in the USA by Borman et al. (2004) and by Crisp et al. (2009) for Hispanic students; in the UK by Rodd et al. (2010); in New Zealand by Hipkins et al. (2006); and by Awad (2008) in Australia. However, by way of contrast, this current study found little evidence of the influence of cultural background and ethnicity on students’ decisions to undertake tertiary mathematics, with just 6% of survey participants suggesting their decisions were influenced by cultural factors.
The impact of parents’ education on students’ choice of course was identified by over a quarter of students. This was most evident for students whose mothers had only primary school education and those whose fathers had post-graduate qualifications, with almost half of these two groups identifying their parents’ education as a factor in the course choice. In terms of parents’ occupations, one in five survey respondents claimed their parents’ occupation had affected their choice of university course, and of these over a half were inspired by their parents’ occupations. This is consistent with existing research (e.g., Hannula et al., 2007). Also consistent with previous research (Hobart et al., 2006), the analysis of both survey and interview data suggested that students coming from families where significant others (e.g., a grandparent) have a mathematical background showed more interest in taking this subject at university.

In the survey, approximately 85% of students identified their families and themselves as being either well off or at least comfortable financially. This is consistent with participation rates in Australian universities, where the rate for students from low socio-economic backgrounds is only 16 per cent (Australian Bureau of Statistics, 2013). These students reported being free to choose their preferred university course, in contrast to others who had to consider the financial cost involved in choosing to study, particularly when relocation was required and it was necessary to find paid work to support themselves while studying. Some students reported that they considered (rightly or wrongly) mathematics to be an area of study requiring the allocation of a considerable amount of time relative to other potential areas of study, thus influencing its perceived cost value and the suitability for combining the study of mathematics with paid work. In the interviews, students explained in some detail the effect of low financial status on their educational pathways and course choices by expressing fear of not completing their course for lack of financial support or swapping to courses that could be completed in a shorter period of time, thus allowing them to move into employment earlier. These choices were influenced by financial status rather than interest in doing those courses (Ma, 2001, 2009; Watt et al., 2007; Panizon & Westwell, 2009). This type of consideration is consistent with the cost value
associated with lost opportunity, time or money (Eccles, 2009a; Perez, Cromley, & Kaplan, 2014).

Despite being identified in previous studies as influential factors – both at university (Pioterowski & Hemasingha, 2001; Davis-Kean, 2005; Ma, 2009; Bowden & Doughney, 2010) and at school (Marks et al., 2001; Wentzel, 2005; Hannula et al., 2007; Ryan, 2009) – parental interest and the influence of peers were considered important by only very small group of survey participants, with 2% indicating Parental interest and 2% indicating Peers’ influence as influencing their choice of mathematics subjects at university. The survey findings differed from the interview findings in this respect, with over half of the students who reported enjoying mathematics in the interviews also reporting benefiting from the support of a family member during schooling (§6.2).

8.3 Limitations of the study

As with much social research this study was subject to some limitations such as low response rates. While almost 400 students completed the survey, due to circumstances described in Chapter 4, the sample was not fully representative of the population of students undertaking first year mathematics, with the sample skewed in terms of the courses being undertaken by the participants at different universities, and in terms of the type of university they were attending. The fact that sandstone universities were over-represented in the survey was likely to skew the survey sample, while the interviewees who had self-selected were not only likely to be more enthusiastic about mathematics but were also twice as likely to have been enrolled in a mathematics major as respondents to the survey overall is another limitation to the possibilities of generalising this study’s findings to the broader population of students studying mathematics at university.

The number and profile of students who participated was possibly also affected by the design of the survey. The initial questionnaire item was an open-ended question, focused on the main research question. While this afforded the collection of open, rich responses of direct relevance to the study, it may have also been off-putting to some potential participants and may in part explain why 30% of
students who registered to respond did not proceed to complete the questionnaire. In retrospect, had the survey been piloted with more students prior to administration, some of these limitations may have been ameliorated.

Classifying courses by the level of required mathematics and identifying prerequisites was also not easy as students in a particular course enrolled in different levels of mathematics depending on their previous grades in the subject. As a result, comparing students by the level of mathematics they were taking was difficult. For example, where mathematics was part of a course in a particular degree in one university, it might have been a prerequisite for the same course in another university. Sometimes where students were required to take one elective subject from list of different subjects including mathematics, they referred to the subject as “compulsory”. The other problem was that similar courses were given different names by different universities. The process of categorizing students according to how mathematics featured in their courses required careful research into the various course structures and requirements, as well as the sometimes confusing responses given by participants to what had been thought would be easy questions to answer, making the final allocation of participants into groups difficult.

Undertaking analysis of the two different data sets (survey and interview) revealed limitations of each approach and pointed to the strengths of combining both methods. Analysis of qualitative interviews does not support the type of generalization that might result from the analysis of quantified data; however, the qualitative analysis pointed to potential misinterpretations of survey responses (for example, the misinterpretation of attainment value as utility value as explained earlier in this chapter).

Different findings emerging from the analysis of the two data sets might also be attributed to differences between the two groups of participants: the entire survey group and the subset who were interviewed. Surprisingly, a third of the students (126 of 345) who responded to the question asking whether or not they would agree to be interviewed were willing to participate. About half of these students were enrolled in a mathematics major, compared to only a quarter of all survey participants. Most of the interviewees were also among students who
nominated the factor *Enjoyment* as their most important reason for choosing university mathematics. Perhaps students with a passion for mathematics who consider study, success, and knowledge in mathematics as integral to their study were more likely to volunteer to participate in the interviews. While this is a limitation of the study in terms of making generalizable observations from the interview analysis, this was not the purpose of this aspect of the project design. While the interviews did provide an opportunity for participants to elaborate on factors identified in survey responses, they more importantly provided better access to the stories of undergraduate students who demonstrate an enthusiasm for mathematics. In this way, the interview sampling bias can be seen as a limitation that needs to be acknowledged so that findings can be qualified, but also as a window into the nuances of intrinsic and attainment value within this field, potentially providing a better understanding of those students who are most passionate about mathematics.

Analysing and classifying interview data and making decisions about which interviewees to select as mini case studies, and how to construct these case studies, involved many steps of selection and data reduction. This was informed by the aims of the study, the research questions and the literature review, resulting in the eleven case studies that were presented in Chapter 6. While this process is necessary for the communication of a large body of qualitative data, it means that only some parts and aspects of the interviews were selected with the intention of presenting data and deriving findings. This is a necessary limitation of translating rich qualitative data into research findings and a research report, where meaning making requires interpretation (Costa & Kiss, 2011). To assist in this interpretative process and the process of communicating the data, the Eccles *Expectancy Value Theory of Motivation* was found to be a suitable frame for interpreting the qualitative data. This choice is defensible based on the efficacy of the model as demonstrated by previous research and its applicability across a wide range of fields, but it provides only one possible view of the data and other choices may have offered other views.
8.4 Implications

The findings of this study have implications for a range of stakeholders in mathematics education, including universities and university educators, schools and teachers, parents and students, and other researchers working in this field. It contributes to what we know about students’ decisions and experiences of mathematics higher education pathways by suggesting new potential emphases in the promotion of undergraduate mathematical study to prospective students.

The study identified influential factors contributing to students’ experience in choosing and pursuing mathematics at university, as well as presenting a set of students’ diverse stories highlighting the positive side of learning and applying mathematics. The study found variation between the factors for students from different courses, which reveals the complexity of these influential factors and their impact on the amount and nature of mathematics taken at university.

The study recognizes the importance of schools and teachers affirming, supporting, and promoting students who are passionate about mathematics and driven by high expectation of success, attainment, and intrinsic values, who are the obvious candidates for enrolment in university courses containing the highest level and amount of mathematics. However, it also points to the importance of promoting success, self-image, and intrinsic enjoyment of mathematics to all school students as a means of increasing the likelihood of students going on to study mathematics at university. This implication is consistent with other studies that have found a strong relationship between achievement, self-image, and enjoyment of mathematics, and it identifies these factors as a characteristic of those students who enrol in high levels of mathematics at university as well as a large proportion of students, more generally, who study university mathematics. It is important to support such experiences and attitudes towards mathematics. The types of self-concepts that might support self-efficacy in mathematical studies, require highly skilled, confident, and enthusiastic mathematics teachers who can affirm the mathematical potential of all students, including those who appear to naturally excel at mathematics and those who do not.
The results of this study could also provide a catalyst for students and parents to facilitate social relations and improve conditions for studying mathematics through knowledge gained about the importance of school experience and the support of influential adults throughout schooling (Griffiths & Whitford, 1986; Crotty, 1998).

This study also points to the potential of universities offering incentives to prospective mathematics students who have limited financial means. Other measures that might relieve financial pressures include more flexible means of engaging in mathematical study that would better support students’ part-time employment. Innovative funding or other mechanisms that stimulate students’ motivation in pursuing mathematics could be another way to help students for whom cost considerations are important to enrol in a mathematics course, particularly for those who need more time to complete mathematical tasks and have to endure study expenses after losing part-time jobs.

Pro-active partnerships between schools, universities, and employers could be employed to counterbalance negative influences of cultural, educational, and social backgrounds on students’ decision to undertake mathematics at university. Such partnerships could support the provision of consistent and accurate information about the types of skills and qualifications required for different industries and roles. These kinds of partnership could reduce the wasted resources involved in students’ false starts at university (that is, enrolling in a course that they then decide is unsuitable) and the time involved in students finding their suitable university course and related employment after completing their undergraduate course.

It is hoped that more students will choose mathematics at university, especially if the problems related to high school students’ lack knowledge of mathematics’ marketability and applications are addressed. Lack of knowledge about university courses and careers involving mathematics that might affect students’ desire to pursue mathematics at university was identified as a negative factor in this study and points to a need for cross-sectoral strategies to respond to this lack. The benefit of gaining mathematical knowledge (e.g., mastery in course,
use in other subjects, and understanding the world) expressed both in the survey responses and by interview participants provide guidance for the development of material for high school careers teachers and for university marketing divisions.

8.5  **Recommendations for future research**

This study identified factors that influenced students’ choice of mathematics at university as described by first year university students. Almost half of the students who participated in this study were undertaking a degree in Science or a combined degree in Science and Engineering, with a further quarter of the students enrolled in a single course in Engineering. Almost 40% of students were only intending to study compulsory mathematics. Students enrolled in different courses exhibited different patterns in their identification of factors influencing their choice of mathematics at university, as did students who were undertaking different mathematics sequences. Further research may be needed to explore in more detail the relationship between students’ different motivational factors, their course of enrolment, and their plans to undertake elective mathematics (including a major) in contrast to only taking compulsory mathematics subjects.

This study found that an influential factor in many students’ decisions to study mathematics at university was their long-held plans for a desired academic course, together with long-term goals involving particular career aspirations, which were often consistent with their self-image as someone who was mathematically able (*attainment value* and *expectation of success*). Students’ mathematics background was often found to have been influenced by a supportive mentor, such as a family member, teacher, impressive individual, or some other source of influence such as a book or even a radio or television program. A strong mathematics background often manifested itself in the form of enjoyment and interest (*intrinsic value*) or self-efficacy and belief in being able to complete mathematical tasks (*expectation of success*). However, some students encountered impediments, such as discouragement from significant others, or lack of financial support (*cost value*).
Further research might be needed into initiatives that could assist in building interest, enthusiasm, and motivation towards mathematics, and hence improving the problem of low enrolment. For example, initiatives might promote both the intrinsic and utilitarian value of mathematics starting from the early years of schooling. Existing initiatives tend to target students in the latter years of secondary schooling (e.g., OECD, 2012), or at the point of transition to university (e.g., Burnett & Larmar 2011). More work that targets the primary years is needed. Such initiatives might also support greater success and self-efficacy in mathematics from a very young age, thus preparing students for success in mathematics at higher levels of education, both in terms of achievement and attitude, and self-image.

Another focus of future research in this field might be on improving communication with prospective students in order to enhance their knowledge of available university courses and careers involving mathematics. Researchers could also study different ways that junior secondary school students could become exposed to the applications of mathematics and its role in science, technology, economics, and other areas.

Furthermore, market research could investigate the effect of reducing university fees or offering financial incentives on the number of enrolments in courses involving mathematics. This sort of initiative has already been put into practice at various times in some Australian universities (e.g., University of West Australia, University of South Australia, Deakin University) and its impact could be investigated.

The importance of drawing new researchers’ attention to multiple data sources and diverse types of data when attempting to determine motivational factors is an important implication of this study, where it was found that student responses could be more confidently interpreted when their perceptions and experiences were elaborated in interview. This was particularly the case for attainment value where aspects of identity are closely related to and might underpin short-term goals.
8.6 Final comments

This study investigated what motivated current undergraduate mathematics students to choose to study mathematics at university. It found a diverse array of factors perceived by students as having informed their decisions. These included background factors, situational factors, self-perception, and perceptions of mathematics as a discipline and as a potential pathway to a future career. I started this study wanting to know more about those students who were most passionate about and most engaged with university mathematics, and how and why they differed from other mathematics students who appeared to me – as a university mathematics lecturer – to be less engaged and less interested in an area of study that I admire. Amongst the complexity of factors described and illustrated, two main things stand out: the relationship between motivation towards mathematical study and course of enrolment, and the role of enjoyment and self-concept in strong engagements with mathematical study.

Different cohorts – based on course of enrolment and the status of mathematics in that course as compulsory, elective or part of a mathematics major or minor – exhibited different patterns in their identification of factors influencing their choice of mathematics at university, with the Bachelor of Mathematics students most likely to point to and articulate intrinsic motivation and the relationship of mathematics to their self-concept and attainment value, while the Bachelor of Engineering students were most likely to point to the role of utility value.

The study demonstrates that enjoyment and admiration for mathematics (intrinsic value), coupled with having a strong sense of ability and self-image in relation to mathematical study (attainment value) is a powerful combination that enables and drives some students to develop and pursue long-term plans and aspirations in mathematics, which sometimes manifests as determination in the face of significant barriers.

These findings suggest that undergraduate mathematics students are a diverse population in terms of their motivation for choosing to study mathematics, but that patterns do exist that might inform university mathematics teaching,
administration and marketing. They also suggest that the seeds of interest, belief, and ability in university mathematics are often planted at a young age, and that strategies intended to increase the number of students who study mathematics at university should take this into account.
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APPENDIX 1  THE ONLINE SURVEY
Factors Influencing Students' Choices of Mathematics at University

Plain Language Statement and Consent

Please click here to read, download or print the Plain Language Statement.

CONSENT

- I have read and I understand the Plain Language Statement.

- I freely agree to participate in this project according to the conditions in the Plain Language Statement.

- I have been given a copy of the Plain Language Statement to keep.

- The researcher has agreed not to reveal my identity and personal details, including where information about this project is published, or presented in any public form.

Do you consent to participate in this research?

☐ Yes
☐ No
Factors Influencing Students' Choices of Mathematics at University

1. Please use the space below to comment on the factors you think have influenced your choice of mathematics subjects or units at university.

2. Which university are you currently attending?

3. What is the name of your current course or program?

4. Was this course or program your first choice?
   - No
   - Yes

5. If this course or program was your first choice please go to Question 7.
   If it was not your first choice, what was your first choice?

6. If this course or program was not your first choice, why do you think you missed out on your first choice?
7. Please give the code of each compulsory mathematics subject or unit that you are enrolled in this semester
   a
   b
   c
d

8. Please give the code of each elective mathematics subject or unit that you are enrolled in this semester
   a
   b
   c
d

9. Are these subjects or units the most advanced mathematics that you could have enrolled in this semester?
   ○ Yes, all of them are at the most advanced level
   ○ Yes, some of them are at the most advanced level
   ○ No, none of them are at the most advanced level

10. If you are enrolled in compulsory mathematics subjects or units as part of your course, would you have chosen to take these if they were not compulsory?
    ○ Yes, all of them
    ○ Yes, some of them
    ○ No, none of them

11. If you found that your future studies involved more mathematics than you expected, how would you feel about this?
12. What were the main reasons for your choice of mathematics subjects or units this semester? (You may tick more than one box):
- They are part of my course or program
- I did well in maths at school
- I want to learn more about maths
- I enjoy maths
- Mastery in maths is important in my course or program
- I am following my peers or friends
- Other (please specify)

13. If you ticked more than one box in the previous question, which of the above was the most important reason for your choice of mathematics?

14. For each of the following, please tick the appropriate box

<table>
<thead>
<tr>
<th>Option</th>
<th>Definitely not</th>
<th>Probably not</th>
<th>Probably</th>
<th>Definitely</th>
</tr>
</thead>
<tbody>
<tr>
<td>I plan to take compulsory mathematics subjects or units next semesters</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I plan to take elective mathematics subjects or units next semesters</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I plan to take a minor in mathematics</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I plan to take a major in mathematics</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I plan to do post-graduate studies in mathematics</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>I expect mathematics to be part of my future job</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

15. If you are planning to do further elective mathematics subjects or units at university (including a minor or major), what are the main reasons for your choice?
16. Who were the main people who encouraged or inspired you to learn mathematics? (You may tick more than one box):

- [ ] Parents
- [ ] Sibling
- [ ] Relative
- [ ] Family friend
- [ ] Primary school teacher
- [ ] Secondary school teacher
- [ ] Private tutor
- [ ] Peer or friend
- [ ] Impressive individual
- [ ] Work supervisor
- [ ] Other (please specify)

17. If you ticked more than one box in the previous question, who encouraged or inspired you most?

18. Were there any people who discouraged you from learning mathematics?

- [ ] No
- [ ] Yes

Please specify if the answer is yes
19. For each of the following, please tick the appropriate box

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I have always liked maths</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I liked maths when I had a good teacher</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I liked maths more in primary school than in secondary school</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>liked maths more in secondary than primary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I liked maths more during the first few years of secondary school</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I liked maths more during the later years of secondary school</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

20. Please use the space below to add anything else you want to say regarding your attitude toward maths at school
21. Which Year 11 mathematics subjects did you take (you may tick more than one box)

- [ ] Highest level mathematics
- [ ] Medium level mathematics
- [ ] Basic level mathematics
- [ ] No mathematics

22. Which Year 12 mathematics subjects did you take (you may tick more than one box)

- [ ] Highest level mathematics
- [ ] Medium level mathematics
- [ ] Basic level mathematics
- [ ] No mathematics

23. If you did mathematics subjects at Year 12, which of the following best describes your result? (If you did more than one subject you may tick more than one box.)

Please indicate the level of mathematics to which the results refer.

<table>
<thead>
<tr>
<th>Highest maths</th>
<th>Medium maths</th>
<th>Basic maths</th>
</tr>
</thead>
<tbody>
<tr>
<td>High distinction</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Distinction</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Credit</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Pass</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Fail</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

24. Do you think the grades you received for your mathematics subjects accurately reflect your achievement in mathematics?

- [ ] Yes
- [ ] No

If no, please explain why

[ ]
25. My country of birth was
- Australia
- Other

Please specify: _____________

26. The country in which I completed Year 12 was
- Australia
- Other

Please specify: _____________

27. My mother's country of birth was
- Australia
- Other

Please specify: _____________

28. My father's country of birth was
- Australia
- Other

Please specify: _____________

29. Do you identify yourself with a particular cultural group?
- No
- Yes

If yes, please specify: _____________
Factors Influencing Students' Choices of Mathematics at University

30. If you identify with a particular cultural group, do you think this has affected your choice of university course?

- [ ] No
- [ ] Yes

If yes, please explain how

[Blank Text Box]
31. My mother's highest level of education was
- Primary school
- Secondary school
- TAFE or diploma course or equivalent
- Bachelors degree
- Post-graduate degree

32. My father's highest level of education was
- Primary school
- Secondary school
- TAFE or diploma course or equivalent
- Bachelors degree
- Post-graduate degree

33. Do you think your parents’ education has affected your choice of university course?
- No
- Yes

If yes please explain how

34. How would you describe your mother's occupation?

35. How would you describe your father's occupation?
36. Do you think your parents' occupations have affected your choice of university course?

- [ ] No
- [ ] Yes

If yes, please explain how
Factors Influencing Students' Choices of Mathematics at University

**Questionnaire Page 9**

37. During your time at secondary school, which of the following would best describe your family's financial situation?

- [ ] Well off
- [ ] Comfortable
- [ ] Struggling

38. Do you think your family’s financial situation has affected your choice of university course?

- [ ] No
- [ ] Yes

If yes, please explain how

39. Which of the following best describes your current financial situation?

- [ ] Well off
- [ ] Comfortable
- [ ] Struggling

40. Do you think your current financial situation has affected your choice of university course?

- [ ] No
- [ ] Yes

If yes, please explain how
41. Please use the space below to add any comments you wish on the factors you think have influenced you in your choice of mathematics subjects or units at university.

42. We hope to interview about 30 students who have completed this questionnaire. Are you willing to participate in these interviews?

☐ No
☐ Yes

43. If you answered yes to the previous question please provide following information. This information will not be revealed to any third party.

Name
Email address
Mobile phone number

44. If you would like to participate in the draw for the chance to win a $50 book voucher please provide the following information. This information will not be used for any other purpose than selecting and informing winners of the vouchers.

Name
Email address
Mobile phone number

Thank you for your help
Thank you

You have selected 'No' in the Consent question, so you do not have access to the questionnaire.

If this was a mistake, please select 'Go back to Consent page'.

If you do not want to take part please select 'Exit survey'.

Thank you for your time.

☐ Go back to Consent page

☐ Exit survey
Thank you for completing this questionnaire

Thank you again for completing this questionnaire – we really appreciate your time and effort.

If you wish to check or change your responses please click on 'Previous'.

When you have finished, please click on 'Submit'.
APPENDIX 2 THE INTERVIEW SCHEDULE

Factors Influencing Students’ Choice of Mathematics at University

Sections 1, 2 and 4 are for all interview students. Section 3 will be tailored for each student, including only a sub-set of the questions provided here depending on the answers given by that student on the previously completed questionnaire. Questions will be included in anticipation of a 30-minute interview.

1. Welcome

- Thank you for coming to this interview and signing the consent form. The duration of interview is half an hour. The questions are similar in focus to those from the survey that you have recently completed and will ask you to elaborate on some of the answers you gave. I am particularly interested in finding out more about... <this would be tailored for particular students, based on their responses. It might include: ... why you decided to study maths at university; ... how your experience of university mathematics has matched with your expectations; or something similar to set the general direction of the interview. The interview should take about 30 minutes.

2. Enrolment information

- Perhaps we could begin by just checking that I have your first semester maths units correct
  - Name each unit from survey & check
  - How did you go in this unit? (for each unit)
- Now I see from your survey that you were planning to take xx as your maths units in semester 2.
  - Are you still taking these units?
  - If not, why not?
- In your survey, you also said that you were planning to ... (take no more maths units/do a minor/ etc)
  - Is this still your plan?
  - If not, why not?

3. Confirming, clarifying, and elaborating on factors influencing the decision to study maths at university

Interview students will only be asked questions from the following sections if they supplied responses to the relevant survey items that should be followed up or clarified because of the relevance of the response to the research questions. The questions listed for these sections are representative of the type of questions that will be asked, based on individual students’ survey responses. A tailored interview schedule will be developed for each interview.
student, containing a sub-set of the questions given below. These interviewer and student will have the student’s original survey responses to refer to if they wish.

**Item 1 -- Factors influencing decision to study mathematics at university**

Confirming survey response:

- In your survey, you mentioned a number of things that influenced your decision to study mathematics at university: <list them or refer to the response>. Is that right? Is there anything you’d like to add to that?

Clarifying details of the response and/or elaborating on the response:

- You mentioned xxx, but I’m not sure I really understand how that influenced your decision. Can you please say some more about that.
- You also mentioned that xx influenced your decision to study mathematics at university. Can you please tell me more about that?

Checking response is complete:

- Looking at your original response to that survey question, is there anything else you’d like to add about the things that influenced your decision to study mathematics at university?

- **Item 5 and 6 - for students whose course or program was not their first choice**

Confirming survey response:

- In your survey, you said this course was not your first choice, is that right?

Clarifying details of the response and/or elaborating on the response:

- You said your first choice was xxx. Can you please say more about what you had most wanted to study, where and why?
- In item 6 you said the reason you missed out on your first choice was xxx. Could you tell me the story of how you came to miss out on your first choice?

Checking response is complete:

- Is there anything else you’d like to add about your choice of university course?

**Item 10 for students enrolled in compulsory maths**

Confirming survey response:

- In your survey, I notice you said that you wouldn’t have enrolled in the compulsory maths subjects if it wasn’t a requirement of your course. Is that right?

Clarifying or elaborating on details of the response:
• Can you please tell me why you wouldn’t have done these subjects <this subject> if they weren’t <it wasn’t> compulsory?

**Item 11 – How you would feel if you discovered you had to do more maths**

Confirming survey response:

• In your survey, you wrote that you would feel xx if you found that your future studies involved more maths than you had expected. Is that right?

Clarifying details of the response:

• Why do you think you would feel that way? <or> Where do you think those feelings come from?
• Do you think those sorts of feelings affect your maths study in other ways (ie. beyond subject choice)?

Checking response is complete:

• Is there anything else you’d like to add about that?

**Item 12 main reasons for choosing maths subjects/units.**

Confirming survey response:

• In your survey, you ticked the following reasons for your choice of mathematics subjects or units <point them out>. Is that right?

Clarifying or elaborating on details of the response:

• One of the reasons you ticked was xxx. I’m interested to hear more about that. <or> How do you think xxx influenced you?
• You also wrote (in the “other” box) that xxx. Could you please elaborate on that? <or> I don’t think I understand what you mean by xxx, can you please explain that.

Checking response is complete:

• Looking at your original response to that survey question, is there anything else you’d like to add about what influenced your choice of maths subjects?

**Item 15 Reasons for planning to take elective maths subjects/units.**

Confirming survey response:

• In your survey, you wrote that you are planning to do some elective maths subjects. Is that right?
• You wrote that your main reason was xxx. Is that correct?

Clarifying or elaborating on details of the response:

• So the main reason for planning to do elective maths subjects is xxx. Can you please elaborate on that?
Checking response is complete:
• Are there any other things that have influenced your plan to do some elective maths subjects?

**Item 16 – People who encouraged or inspired you to learn mathematics.**

Confirming survey response:
• In your survey, you selected <name persons selected>. Is that right?

Clarifying or elaborating on details of the response:
• Can you please explain how xxx encouraged or inspired you?

Checking response is complete:
• Are there any other people that you can think of who influenced you decision to study mathematics?

**Item 18- people who discouraged you from learning mathematics.**

Confirming survey response:
• In your survey, you mentioned <person been mentioned> has discouraged you from learning mathematics. Is that right?

Clarifying or elaborating on details of the response:
• Can you please explain how xxx discouraged you?

Checking response is complete:
• Are there any other people that you can think of who affected you interest in learning mathematics?

**Item 19- Your attitude towards maths at school.**

Confirming survey response:
• In your survey, you selected <I liked maths at...> more than .....Is that right?

Clarifying or elaborating on details of the response:
• Can you please explain why you like maths at....more than...?

Checking response is complete:
• Are there any other periods of your schooling in which you liked mathematics and why?
• Is there anything else that you want to say about your attitude toward mathematics?

*<similar questions for other sub-questions in Item 19, where of interest>*

**Items 21 & 22- your senior school maths subjects.**
Confirming survey response:

- In your survey, you indicated that the level of mathematics you completed at high school was xxx. Is that right?

Clarifying or elaborating on details of the response:

- Can you please explain why did you studied mathematics to that level?

Checking response is complete:

- Is there any other thing that you want to say about why you studied to that level of mathematics at school?

**Item 24 the relation of your senior school maths grade to your achievement**

Confirming survey response:

In your survey, you said the grade you received for your maths did not accurately reflect your understanding of what you had learnt. Is that right?

Clarifying or elaborating on details of the response:

- What do you think led to this situation? Or why didn’t your grades reflect your understanding?

Checking response is complete:

- Would you like to add more about the grades you received for maths at school?

**Item 30 the affect of your culture on your choice of university course?**

**For students who answered yes:**

Confirming survey response:

- In your survey, you indicated that your culture influenced your choice of university course. Is that right?

Clarifying or elaborating on details of the response:

- Can you please explain how your culture has affected your choice of university course? Or On your survey you said that xxx <ie. is how cultural background has influenced> had an effect. Could you please say some more about that?

Checking response is complete:

- Is there anything else you’d like to add about the affect of your cultural background on your plans for university study?

**Item 33 the affect of your parents’ education on the choice of your university course.**

**For students answered yes to the question**
Confirming survey response:

In your survey, you said your parents’ education influenced your choice of university course. Is that right?

Clarifying or elaborating on details of the response:

- On your survey you said that xxx <i.e. is how parent’s ed background has influenced> had an effect. Could you please say some more about that? Or Can you please explain how your parents’ educational background has affected your choice of university course?

Checking response is complete:

- Is there anything else you’d like to add about the affect of your parents’ education on your plans for university study?

**Item 36 the affect of your parents’ occupation on the choice of your university course.**

For students who answered yes to the question

Confirming survey response:

- In your survey, you said your parents’ occupation influenced your choice of university course. Is that right?

Clarifying or elaborating on details of the response:

- On your survey you said that xxx <i.e. is how parent’s occupation has influenced) had an effect. Could you please say some more about that? Or Can you please explain how your parents’ occupation has affected your choice of university course?

Checking response is complete:

- Is there anything more you’d like to add about the affect of your parents’ occupation on your plans for university study?

**Item 38 the affect of your parents’ financial situation on the choice of your university course.**

For students who answered yes to the question

Confirming survey response:

In your survey, you said your parents’ financial situation influenced your choice of university course. Is that right?

Clarifying or elaborating on details of the response:
• On your survey you said that xxx <ie. is how parent’s financial situation has influenced) had an effect. Could you please say some more about that? Or Can you please explain how your parents’ financial situation has affected your choice of university course?

Checking response is complete:
• Is there anything else you’d like to add about the effect of your parents’ financial situation on your plans for university study?

Item 40 the affect of your financial situation on the choice of your university course.

For students who answered yes to the question

Confirming survey response:
• In your survey, you said your financial situation influenced your choice of university course. Is that right?

Clarifying or elaborating on details of the response:
• On your survey you said that xxx <ie. about how their financial situation has influenced) had an effect. Could you please say some more about that? Or Can you please explain how your financial situation has affected your choice of university course?
• Is there any sort of assistance or program or degree structure that might have helped with your situation?
Checking response is complete:
• Is there anything else you’d like to add about the effect of your financial situation?

4. Thank-you

• Thank-you for your time