Copyright Statement

The digital copy of this thesis is protected by the Copyright Act 1994 (New Zealand).

This thesis may be consulted by you, provided you comply with the provisions of the Act and the following conditions of use:

- Any use you make of these documents or images must be for research or private study purposes only, and you may not make them available to any other person.
- Authors control the copyright of their thesis. You will recognize the author's right to be identified as the author of this thesis, and due acknowledgement will be made to the author where appropriate.
- You will obtain the author's permission before publishing any material from their thesis.

General copyright and disclaimer

In addition to the above conditions, authors give their consent for the digital copy of their work to be used subject to the conditions specified on the Library Thesis Consent Form and Deposit Licence.
Factors that influence science and non-science option choices in Year 13 at one New Zealand secondary school: Students’ voices.

Sutapa Mukund

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Education in Education.
The University of Auckland, 2019
Abstract

The Trends in International Mathematics and Science Study (TIMSS) report from 2015 indicates that over the last 20 years there were some declines and no increases in students taking Science Technology Engineering and Mathematics (STEM) subjects. Yet, this technologically advanced world is evolving more towards STEM jobs. It might be thought that students would choose disciplines, especially science and technology ones that provide stepping-stones to careers. However, not all student decisions are based on science career prospects. It is difficult to assign a single factor to such decision making. This case study, carried out in a low decile secondary school in South Auckland, aimed to understand the fundamental factors that influence such decision making among young adults in pursuing science or dropping science in their final year of high school. The study aimed to explore five salient factors that influence decision making and have been commonly mentioned in the literature. These included intrinsic interest and motivation in science, socializer influences, situational influences provided at school, career motivation, science self-concept and self-determination.

The study followed a Sequential Explanatory design using a mixed methods approach. Data were gathered from a 25 items survey administered to all participating Year 13 students followed by semi-structured interviews of 5 students taking one or more subjects in science and 5 students not taking science in Year 13. Combined data sets were used to draw a conclusion to this enigma of adolescent decision making.
Acknowledgements

I would like to acknowledge my gurus, Dr Gillian Ward and Dr Aaron Wilson for accepting me as their student and supervising me through this study.

The ancient Sanskrit word guru refers to a teacher who is an expert or a master of knowledge. The guidance received from my gurus, Dr Ward and Dr Wilson was immeasurable during this educational journey. A very steep learning curve, that I would not have been able to traverse without their expert guidance, direction, and extreme patience. I wish to thank you for this.

I would like to acknowledge the Auckland Airport for their magnanimous endowment of a study award for teachers in South Auckland Schools, that assisted me financially through the course.

I am grateful to the members of the Board of Trustees at Papatoetoe High School and the Principal, Mr Vaughan Couillault without whose support this study would not have been possible.

The Ministry of Education – New Zealand, is acknowledged for the study award that professionally helps teachers to better equip themselves in the classroom.
Dedications

This study is dedicated to you - Keith Andrew Ripper.

I would never have completed my research without your persuasion and encouragement.

You have always believed in me even when, at times, I did not believe in myself.

For your relentless support, and determination not to give up on me, I will always remain indebted to you.
# Table of Contents

Abstract.................................................................................................................................i

Acknowledgements.............................................................................................................. ii

Dedications ............................................................................................................................. iii

Chapter One: Introduction .................................................................................................... 1

1.1 Introduction...................................................................................................................... 1

1.2 Researcher’s background and the rationale to this research study ......................... 1

1.3 Focus of the research questions .................................................................................... 3

1.4 Research design .............................................................................................................. 4

Chapter Two: Literature Review ............................................................................................ 6

2.1 Introduction...................................................................................................................... 6

2.2 Outline of this chapter .................................................................................................... 6

2.3 Why Learn Science? .................................................................................................... 7

2.3.1 Democratic or citizenship purpose ........................................................................ 8

2.3.2 Utilitarian Purpose .................................................................................................. 9

2.3.3 Pre-professional training purpose ......................................................................... 10

2.3.4 The Cultural and Intellectual purpose .................................................................. 11

2.4 Decline in the number of students taking science. Concern or crisis? ..................... 12

2.5 Factors that influence students’ subject selection choices ........................................ 14

2.5.1 Attitudes to science ............................................................................................... 16

2.5.2 The classroom environment .................................................................................. 17

2.5.3 The science curriculum ......................................................................................... 19

2.5.4 The influence of family, peers and career counsellors ........................................ 21

2.5.5 Careers for the future ........................................................................................... 23

2.6 Self-determination theory and its influence on decision making .............................. 24

2.7 Self-concept and its impact on decision making .......................................................... 24

2.8 Conclusion ................................................................................................................... 25

Chapter Three: Methodology ................................................................................................ 27
Table of Figures and Tables

Table 1 Model for Mixed Methods Sequential Explanatory Design ........................................31
Table 2 Stages of Mixed Methods Data Analyses Process .......................................................49

Figure 1 Percentage of participants from Year 13 students taking science or not taking science based on ethnicity ........................................................................................................52
Figure 2 Response to individual interest in science ..................................................................53
Figure 3 Response to the ease of understanding science in Years 9 and 10 ............................54
Figure 4 Response to the application of science to everyday life ..........................................55
Figure 5 Response to external factors in decision making ......................................................56
Figure 6 Response to peer influence on subject choice .........................................................57
Figure 7 Response to parent and family influence on subject choice .....................................58
Figure 8 Response to science self-concept ..............................................................................59
Figure 9 Response to the ease of understanding science concepts ........................................60
Figure 10 Response to the attainment of grades .....................................................................61
Figure 11 Response to engagement in science classes ............................................................62
Figure 12 Response to attentiveness in class with life examples ............................................63
Figure 13 Response to group discussions making lesson interesting ......................................64
Figure 14 Response to the importance of science for career and employment prospects ....65
Figure 15 Response to understanding science in relation to career benefits ............................66
Figure 16 Response to subjects selected in relation to university study ..................................67
Figure 17 Thematic Map showing the 4 main themes ..............................................................69
Chapter One: Introduction

Science means constantly walking a tightrope between blind faith and curiosity; between expertise and creativity; between bias and openness; between experience and epiphany; between ambition and passion; and between arrogance and conviction - in short, between an old today and a new tomorrow. Heinrich Rohrer (1933-2013)

1.1 Introduction

The quotation above from the Swiss physicist and Nobel Laureate, Heinrich Rohrer, discoverer of the scanning tunnelling microscope, encapsulates the motivation for this research.

Designer babies, world hunger, climate change, space colonies, social inequity, economic injustice, automation, alternative fuels - we live in a time of amazing innovation, but also of significant challenge. We need citizens who can recognise bias, separate fact from fiction, analyse data and problem solve. For this, we need citizens who are scientifically literate. This does not mean that all students need to become scientists, what it does mean is that all students need to understand the importance of science and scientific thinking.

Science has never been more important. Decisions made today will affect the planet’s future. We need to see the bigger picture for the future, a future where individuals can make personal informed decisions in this scientific world without predisposition. Yet, globally there is a definite decline in the numbers of students taking science after the compulsory years. My quest to find answers to this decline especially in New Zealand, and more so among students in the lower socio-economic areas, underpins this study.

Section 1.2 describes my personal background and defines the reasons behind this research study. Section 1.3 explores the focus of the research questions and section 1.4 provides an outline of the research design.

1.2 Researcher’s background and the rationale to this research study

I grew up in India. I was a very curious child. I snooped around the garden; was chided for bringing home an almost dead bat (*Pteropus giganteus*) and was told off when I tried to taste berries that were deemed to be poisonous. I was keen to solve mysteries that seemed of little interest to all others.
No one was interested in knowing what happened to the hundreds of hairy-scary caterpillars on our drumstick (*Moringa oleifera*) tree. They appeared suddenly from nowhere in the summer months and then disappeared in the next two months.

I was sent to a private school and a private college to complete my education before pursuing higher studies at University. My parents were middle-class people. They sacrificed their life to put me through this private education. Why?

Like many Indian parents, mine believed, that the most significant wealth that I would receive from them would be a sound and solid education. It was oft repeated by the elders, that to succeed in life you needed a major degree. Academic studies in India are not only a status symbol for the entire family but also a necessity to get a reasonably good job and to progress in a highly competitive society. Simply translated, it follows Darwin’s theory: Survival of the fittest.

Ironically, school science was never my thing. I loved History and the Arts because the teachers told us many ancient and meaningful stories. In Art, I had the freedom to paint what I wanted. But my parents would have nothing to do with those subjects. I did extremely well in all my science assessments and so science became my future subject by default. Science at school held little interest for me as I was often bored by the transmissive pedagogy. This was central when I decided to be a teacher of science. I decided to change the science classroom for my students. I wanted it to be exciting and fun filled with stories and activities.

Having taught science for over thirty-two years in different parts of the world, the last twenty spent in New Zealand, I have always found myself trying to bring innovative teaching methods into my classes keeping written work to a minimum. Interestingly, over this long period of time, diverse students in various schools in different countries often displayed many similarities. Students in junior classes seemed to enjoy science. If assessments were low stake such as topic tests, or if the end of year assessments did not impede the entry or continuity of science into the next year level, students enjoyed the subject and were actively involved. High stake assessments frazzled the students in senior classes. Marks, credits and grades were pivotal to all conversations. Completing the syllabus to achieve desired grades thus became the most important criterion in all senior science classes.

Secondary school science teachers the world over, especially in low socio-economic neighbourhoods are commonly faced with a decline in student numbers in physics, chemistry and biology in the final years of schooling. Science seems to be a dreaded subject by many students. Students often remove science from their timetable as soon as the compulsory years
of science learning is completed. For many, this is at the end of Year 10 in New Zealand. Some pursue it in Year 11 and then again, we see a further disappearing act in Years 12 and 13. As the curriculum grows in content in senior years, students drift in to other subjects which they perceive as easy. Parents played a major role in influencing student subject choices particularly, for some ethnicities and those from higher socio-economic backgrounds. These were personal experiences as a student and as a teacher.

I have been teaching in low decile South Auckland schools for over two decades. This has been a personal choice. I have taught in elite and highly competitive private schools abroad, but teaching in low decile schools, where I am able to make a difference and motivate students, brings greater personal satisfaction.

At department meetings the science staff have often discussed at length the possible causes for the declining student numbers in traditional science classes. We have had to answer questions put by the senior management as to why student numbers were dropping, and why results have been unsatisfactory. What could we do to motivate students to take science? However, the discussions always centred round our own opinions. We never really asked the students why they were shying away from science. This seemed wrong to me. And so, began the idea of carrying out a research with a focus on student voice.

1.3 Focus of the research questions
A growing need for more science graduates in STEM subjects has been advocated universally. To date there remains grave concern about equity regarding the implementation of STEM education and student participation in STEM worldwide (Archer, Dewitt, & Osborne, 2015). It continues to be stratified by ethnicity, gender, and social class (Archer, Dewitt, & Osborne, 2015). Statistics from the United Kingdom and United States indicate that, in general, those from minority ethnic backgrounds are underrepresented in physical science degrees (Adamuti-Trache & Andres, 2008; Ceci, Wiliams, & Barnett, 2009; Smith, 2011; Archer, Dewitt, & Osborne, 2015). Like the Black, Pakistani and Bangladeshi students in the United Kingdom and United States who are less likely to work in science, engineering, and technology professions (Elias, Jones & McWhinnie, 2006; Archer, Dewitt, & Osborne, 2015) there exists the under representation of Māori and Pasifika in New Zealand tertiary science (Hipkins, Roberts, Bolstad & Ferral. 2006).

Observation from our own school’s personal data showed a decreasing percentage of students taking NCEA Science in Years 12 and 13. The Programme for International Student Assessment (PISA) report of 2015 for New Zealand Schools states that there are larger
proportions of students with low performance in science, reading and mathematics than there were before 2012. The 2012, PISA report states that Māori and Pasifika student performances were on average significantly below the OECD average. A lower proportion of Māori and Pasifika students achieved at the highest levels of proficiency in science, and these students were over-represented at the lower levels when compared to the New Zealand average. Low achievement might well be a factor influencing students option choices in Year 13.

Over several educational conversations with teachers from different countries and engaging with professional readings I was keen to find out why we were not meeting the expectations of many of our students. Why were we not able to sustain the interest of our young and curious Year 9 and 10 students into continuing with science in senior years? The desire to understand how students made their choices to choose specific subjects was vital. How could we as teachers of science shape the future of our students, engage them in science, use innovative pedagogy and motivate more children to follow a scientific conduit?

Thus, began my journey. A quest to understand student voices. What did they feel? How did they process their thoughts in making these significant decisions? My pursuit of these intense questions formulated my research focus and I designed the following questions:

- Why do students select science in secondary schools?
- Why do students refrain from selecting science in secondary schools?
- What attitudes do students hold towards science?
- What intrinsic & extrinsic factors influence their decisions to study science in Year 13?

1.4 Research design
The study is covered in eight chapters. Chapter 1 has outlined how the research questions were formulated based on my personal experiences and need to seek answers from students’ voices. Chapter 2 explores the literature from various studies. It first establishes why science learning is of paramount importance today. It draws upon the work of several researchers who have discussed the range of factors that influences students’ decision making in their final years. Chapter 3 details the mixed methods approach followed by the researcher. It details the gathering of quantitative data and qualitative data after completing a rigorous and arduous process of ethics approval as the study involved students within a social research setting of a particular secondary school in South Auckland. Chapter 4 presents the details of all the findings tabulated graphically from an online survey followed by semi-structured interviews with both science and non-science participants. Chapter 5 engages the reader with the discussions of the results of this study in context of the literature. Chapter 6 summarises the
study with a succinct conclusion, describing the implications and significance of the discussions for science educators and policy makers. It reinforces some of the aspects of the literature already known to us and emphasises directives that could possibly help to attract more secondary students into science courses. The conclusion also urges educators to explore inquiry projects that could benefit the teaching fraternity and strongly voice their opinions towards changes in both the curriculum and the methods of assessment. Appendices and references are annexed in the last few pages after the conclusion.
Chapter Two: Literature Review

2.1 Introduction

The current environment of the 21st century is the era of industrial revolution 4.0. Cyber physical systems, management and manufacturing of chain productions dominated by science and technology are evident everywhere. Careers related to science, technology, engineering and mathematics (STEM) are abundant (Bybee, 2010). STEM jobs underpin health care, food production, manufacturing, and the world economy. Yet, we are currently faced with declining enrolments in secondary science subjects in schools around the world (De Laeter & Dekkers, 1997; NRC, 2003; Osborne Simon, & Collins, 2003; Kennedy, Lyons & Quinn, 2014; Wilson & Mack, 2014, De Silva, Khatibi & Azam, 2018). The follow-on effect is evident at the tertiary level of education (Hipkins, Roberts, Bolstad & Ferral, 2006; Lyons & Quinn, 2010) and predicted STEM workforce shortages (Augustine, 2005; Xue & Larson, 2015).

Students reluctance to participate in science subjects like biology, chemistry and physics is of global concern. This has been discussed widely and debated over the last three decades in the literature (Fullarton & Ainley, 2000; Osborne, Simon & Collins, 2003; Braund & Reiss, 2006; Bøe, Henriksen, Lyons & Schreiner, 2011). The teaching and learning of science continue to be a primary directive on the global educational agenda at schools and at universities (Bush, 2001; National Science Foundation, US, 2003; Clark & Dickson, 2003; National Research Council, 2007; Gluckman, 2011; Buntting, MacIntyre, Falloon, Cosslett & Forrret, 2012; Ministry of Education New Zealand, 2014) to increase participation in science.

In this chapter I attempt to find reasons for the falling secondary enrolments in science subjects, focussing on the issues faced by the students who are often voiceless in our system.

2.2 Outline of this chapter

This study firstly examines the literature from available research to establish why science is vital in these challenging times. The study then continues to examine the multitude of factors that encourage or deter secondary school senior students from pursuing science as a subject in their final year of secondary education in New Zealand. It concludes with how these issues may be addressed to enhance greater science participation in the future.

Section 2.3, in this chapter, establishes why an education in science really matters to the learners of the 21st century. This section also explores key ideas from different perspectives, as to why science education needs to be promoted in secondary education in keeping with the changing times. Section 2.4 examines the probable causes for the decline in the numbers of
students taking science. Section 2.5 examines factors that impact decision-making in adolescents. Section 2.6 inspects the self-determination theory and its relation to decision making among 21st century learners. Section 2.7 reviews how self-concept may influence an individual’s decision making. Section 2.8 concludes the chapter with a justification of the research questions on decision making among adolescents.

2.3 Why Learn Science?

A major decision that New Zealand adolescents deliberate over, is their choice of subject options from Years 11 to 13. Their decisions subsequently impact on their transition to tertiary studies at university (Hipkins, Roberts, Bolstad & Ferral, 2006) technical institutes, vocational pathways or careers. The literature aims to understand underlying factors, that play a pivotal role in this process of decision making.

In a world filled with products of science and technology, scientific literacy is essential for making informed decisions. From designer babies to alternative medicine, from transport options to business transactions it could be argued that the overarching purpose for learning science is to enable learners to critically question and to evaluate information (Roberts & Bybee, 2014). One of the purposes of learning science is to be able to distinguish myth from fact. In the 2003, OECD publication of the PISA, Assessment Framework, Millar and Osborne (1998) state that the modern science curriculum should focus on reading and allowing scientific literacy. They further elaborate that:

In this approach, the emphasis is not on how to “do science.” It is not on how to create scientific knowledge, or to recall it briefly for a terminal examination….Thus in science students should be asked to demonstrate a capacity to evaluate evidence, to distinguish theories from observations and to assess the level of certainty ascribed to claims advanced. Millar & Osborne (1998) in OECD (p, 132, 2003)

In a study commissioned by the Royal Society through the New Zealand Council for Educational Research (NZCER), Bull, Gilbert, Barwick, Hipkins & Baker (2010), outline four wide-ranging purposes of teaching and learning science in New Zealand schools.

- a democratic or citizenship purpose
- utilitarian purpose
- pre-professional training purpose
- a cultural and intellectual purpose.
These teaching and learning purposes are further endorsed by Bolstad, Bull, Carson, Gilbert, MacIntyre and Spiller (2013). Their studies support the fact that such learning purposes can be enhanced and strengthened by engagements between schools and the science community and strong home-school partnerships. These views are further reinforced by literature from several studies (Eccles & Harold, 1993; Epstein, 1995; Epstein, 2001; Henderson & Mapp, 2002; Bull, Brooking & Campbell, 2008). The four key purposes as to why acceptance of science needs to be amplified among secondary students is discussed in the following section.

2.3.1 Democratic or citizenship purpose

The democratic or citizenship purpose can be accomplished by building on an individual’s scientific literacy (Jenkins, 1999, Bull et al., 2010). According to the United States National Science Education Standards (NRC, 1996, p.22) “scientific literacy is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity.”

While science has altered our lives positively it has also resulted in disruptive innovation and technology (Christensen, Raynor & McDonald, 2015) and wicked problems (Rittel & Webber, 1974). Wicked problems as defined by Head and Alford (2015, p.712) refer to “those problems that are complex, unpredictable, open ended, or intractable.” Scientifically based disruptive technologies such as, sophisticated medical innovations, bio-printing of tissues and organs, autonomous vehicles and space colonisation are close to becoming reality. Automated customer services including banking using biometrics, e-commerce and businesses such as Uber, Airbnb and e-newspapers are already here to stay, having displaced previously established technology, markets and values. Disruptive technologies have axed numerous job roles, but only improved the quality of life for some, while bringing volatility, uncertainty, complexity and ambiguity (VUCA) for most.

Such rapid changes as automation in manufacturing and construction, or the use of drones to deliver packages, instil the fear of technocratic control (Hewitt, 1983; Longbottom & Butler, 1999; Rotman, 2013) in people. How humans perceive their material world, accept or reject technological changes depends on our understanding, scientific thinking and scientific literacy (Longbottom & Butler, 1999). This is aptly highlighted in the quote below:

“Nothing in life is to be feared, it is only to be understood. Now is the time to understand more, so that we may fear less. — Marie Curie (1867 - 1934)
Disruptive technologies hinge on both science and scientists. A small group of expert scientists are often at the helm of affairs taking ownership for breakthrough discoveries in for example, the way biotechnology is changing health, medicine, industry and even the food we eat. While it is not customary for the public to have in-depth technical know-how of how these technologies work, the readiness for their use and acceptance in society is critical. It is vital that the public is aware of the science and processes behind these discoveries. Rather than theoretical knowledge, procedural understanding based on evidence is critical in promoting rational decision making (Duggan & Gott, 2002). To sustain a healthy democracy, it is imperative to have a scientifically literate population who can understand and question the implications of economical, ethical and moral changes. This is further supported by the NRC (2007) and OECD (2018) reports that urge the need for a change in the growth mindset of our students.

Disruption in society using technology, can be minimised with open science and science communication (OECD, 2018). Miller (1987, 1992) and Miller (2001), have provided several examples of how controversies and debates on scientific issues, dispersal and uptake of information can occur better when public are scientifically literate. In an interview aired on Science Today (2016) questioning the influx of science and technology, Neil deGrasse Tyson, fittingly replied “I see science and technology and creative investments as the most significant infusion to our economy that can possibly be conceived”.

The need to enhance scientific literacy among adolescents is further justified by the fact that understanding science improves one’s critical thinking. This tenet is powerfully advocated by several researchers (De Boer, 2000; Miller, 2001; Roberts & Bybee, 2014).

2.3.2 Utilitarian Purpose
Not all students who take up science in school will necessarily follow a career in science. However, it is important that students are equipped with practical knowledge, new skill sets and experience in readiness for the world (Bull et al., 2010). While it can be argued that most knowledge is easily available at our finger tips in this digitised world and science can be self-taught, it can also be counter argued that the digital revolution is accelerating innovation, sometimes beyond comprehension (Brynjolfsson & McAfee, 2012). Rather than being pessimistic about this digital frontier, the purpose of science is to empower students to evaluate information and provide them with transferable skill sets to benefit the society. This is detailed in the OECD (2012) report on how appropriate skills lead to successful jobs and an improved lifestyle.
Engagement with the scientific community can provide authentic and relevant science that will motivate students to connect with their local community or wider society in meaningful ways (Bolstad et al., 2013). Outreach programmes offered by the New Zealand Marine Studies Centre (Otago University), Chemistry Outreach (Otago University), National Sea Week (Department of Conservation), Light Outreach (Photon Factory, University of Auckland) are examples of many such drivers that enthuse students to appreciate science. Studies reported by Falk and Dierking (2000) using museums, both real and virtual, as spaces and places of learning could enhance this utilitarian value. Such experiences often attract students who are bored with content laden, less challenging science in the regular classroom (Osborne & Collins, 2001) to view the understanding of science using the utilitarian lens.

2.3.3 Pre-professional training purpose

One important purpose of teaching and learning science is to equip students with skills and a growth mind set (Hochanadel & Finamore, 2015). A growth mindset allows skills and intelligence to be consciously developed over time and enhances achievement. Claro, Paunesku and Dweck’s (2016) empirical research with large population samples of 1500 grade 10 participants in two separate randomised studies across Chile is a classic example that shows that a developing growth mindset augments success. If students’ intellectual abilities can be developed alongside changing times it would allow them to develop grit, hone their skills and prevail against all adversity in this dynamic world (Hochanadel & Finamore, 2015). Trade specific jobs requiring technical skills are constantly being replaced in this shifting landscape with many jobs now requiring totally different skill sets - including creativity, critical thinking, collaboration and communication (Ministry of Education, 2014). The major need to support the learning of science at secondary school, is to increase students’ awareness of these skill sets. Science education needs to empower them with a growth mindset in preparedness for STEM careers (NSB, 2003) relevant to the changing times and acceptance of new state-of-the-art jobs.

New Zealand’s economic and social wellbeing depends on the productivity and competitiveness of the economy and the knowledge we have to help make informed decisions as a society. Innovation that leads to increased productivity and promising solutions to society’s most pressing concerns is increasingly being seen around the world as an important way to generate economic growth and improved living standards.

(Madsen, 2014, A Nation of Curious Minds, p.15)
2.3.4 The Cultural and Intellectual purpose

In this section it is argued that science must be a priority for certain groups of the population in New Zealand who are underrepresented in this discipline. The cultural and intellectual purpose of teaching and learning science reflects Plato’s philosophy of allowing all individuals to develop excellence in education by encompassing intellectual enculturation (Bull et al., 2010). Chapple, Jeffries and Walker (1997) mention the considerable education gap between Māori and non-Māori students and its consequence in the labour market performance. This achievement gap though narrowed today, still poses a concern. In their report *Indicators of Inequality for Māori and Pacific People*, Marriott & Sim, (2014) point out several inequalities including, low secondary school retention rate for Māori students, a higher rate of Māori youth not in education or employment or training (Te Puni Kōkiri, 2012) This inequity is further reflected in science disciplines from the reports mentioned below.

The organisation for Economic Co-operation and Development (OECD) that administers the Programme for International Student Assessment (PISA) aims to evaluate education systems worldwide by testing the skills of 15-year-old students in reading, mathematics and science. It provides comparable data in student achievement and is a good indicator of the country’s progress both in comparison to other countries and within the country itself. What stands out from the 2015 PISA report is the continuing inequity similar to the 2012 PISA report, especially for Māori and Pasifika students, who have been traditionally underserved in our education system in New Zealand. Māori and Pasifika students’ overall performance were significantly lower than the OECD average in both 2012 and 2015. A lower proportion of Māori and Pasifika students achieved at the highest levels of proficiency in science, and there exists a wider gap between the top 10% and the bottom 10% of results in New Zealand as compared to all other participating OECD countries in science.

The urgent need for teaching science and ensuring that it is all inclusive is to target this ongoing inequity in Māori and Pasifika students since they are the future of New Zealand. Science needs to attract and empower groups of individuals, inclusive of all cultures, especially those who are currently underrepresented in society. The Science Wānanga is a classic example, helping Rangatahi Māori in their individual pathways. The Health Science academies in South Auckland provide opportunity and support to Pacifica students joining the health force. Science teaching and learning can happen over a whole-body of learning through experiential ways outside of conventional classrooms to lessen the inequity gap.
While the demand for science graduates is increasing globally, we seem to be faced with a shortage of science graduates the world over. Are we faced with a crisis or is it just a concern that can be addressed? The ensuing section voices concerns over the demand-supply issues and tries to understand the anxiety over declining numbers in science enrolments at secondary schools.

2.4 Decline in the number of students taking science. Concern or crisis?

In New Zealand, secondary school students most commonly make their subject option choices in Year 11 or Year 12 at the average age of 16/17 years. While most students continue into Year 13 with the same subjects, some students may change their subject choices in their final year of schooling prior to tertiary education or directly embark on careers via apprenticeship and career pathways or youth guarantee programmes.

In a study that looks at why fewer people are opting for science at tertiary study in New Zealand, Hipkins, Vaughan, Beals, Ferral & Gardiner, (2005) have described a multiple factor interplay in such choice patterns. They surmise that the problems begin at secondary school, where numbers are declining nationally, in the enrolment of students in the traditional science subjects of physics, chemistry, biology, and general science. In a further study, Hipkins, Roberts, Bolstad & Ferral (2006) have reported how the number of students enrolling in tertiary level science in New Zealand are also declining and link this to early trends in secondary schools. Sadly, while opportunities exist, there is a tremendous risk of losing adolescents to several desirable jobs in science and STEM (NRC, 1999).

There often exists an assumption that students have the freedom to choose their option subjects in Year 13. However, such choices do not always apply to all students. There are many crucial factors that interplay and influence decision making (Cleaves, 2005; Hipkins, Roberts, Bolstad & Ferral. 2006). These range from students who want to take science subjects like physics, chemistry and biology, but do not meet the prerequisites for science options as prescribed by individual schools or, conversely, are adept at science and yet prefer not to pursue it. In fact, school factors such as what subjects are offered by the school, the prerequisite to a course, and the timing of course selection are factors that have been ignored or downplayed (Smyth & Hannan, 2006). These prerequisites and grades are often stumbling blocks to entry into senior science disciplines (Schiller & Muller, 2003).

It is also important to have an insight into the way schools in various countries presently offer diverse subjects to allow for career pathways. In many New Zealand and Australian schools, a
wide range of subjects are currently available alongside the traditional science subjects of physics, chemistry and biology (Lyons & Quinn, 2010). Students can opt for health science, home economics, food technology, environmental science, science for sustainability, earth science, agriculture/horticulture, animal husbandry, marine studies, electronics, hospitality, psychology and other science related subjects in preference to more narrowly focussed academic disciplines like physics, chemistry and biology. This raises the question of whether enrolment numbers are really declining in science or have science related subjects expanded and need to be classified alongside the traditional subjects of physics, chemistry, biology.

From a detailed study in Australia involving both science teachers ($N=589$) and students ($N=3759$), Lyons and Quinn (2010) recognize that a similar trend of falling numbers in enrolment is also seen in economics, history, geography and advanced mathematics. The availability of a greater array of new subject options available to students seem to indicate the decline in lower enrolments in traditional subjects in the arts as well as science. De Laeter and Dekkers (1997) as well as Lyons and Quinn (2010) confirm that a key factor for the proportional decline in science enrolment in Australian secondary schools is the availability of alternative science subjects with a multidisciplinary focus. This is further supported through recent studies conducted by Kennedy, Lyons and Quinn (2014) who propose that the broadening of curriculum offerings along with several other variables such as perceived subject difficulty, and the usefulness of the discipline, and students’ self-perception, all influence subject options.

Evidence from the literature indicates that a considerable proportion of 21st century students are following definite trajectories or career paths to specific dream jobs (Lent, Brown & Hackett 1994; Cleaves, 2005; Lyons, 2006). They are strategically choosing specific disciplines that lead to better paid careers. Academically sound science students may be dropping science subjects for business, media, digital technology or economics as these subjects are more attractive career wise. There is definite evidence that indicates monetary incentives influence decision making (Gneezy & Rustichini, 2000). These are possible attributing factors to the falling numbers in students choosing traditional science subjects.

A typical example is provided in a study by Garg and Gupta (2003). They describe a shift in subject priority exemplifying that secondary students in India have been drifting out of specific science subjects like physics, in preference for technical courses and more diverse science related subjects such as materials and processing and electronics that can still lead them to a science related career, albeit not in traditional science. This is echoed in the findings of Lyons and Quinn (2010) in Australia. They have reported that science teachers believed that
student enrolment had increased for less academically demanding courses and this preference was heightened by the expanded range of subjects on offer. Different academic pathways to careers available in New Zealand secondary schools may well be another reason for declining science enrolment in traditional science subjects (Vaughan, 2005).

If the various science related subjects and traditional science subjects were to be amalgamated under the umbrella of science, research may well provide clearer statistical information for future studies. This leads us to further explore what other factors may detract students from taking traditional science subjects such as physics, chemistry and biology in their final years at school.

2.5 Factors that influence students' subject selection choices

This section initially examines several general factors influencing decision making, including student’ interest, curiosity and the impact of experiences in primary school. The study then discusses specific factors including attitudes to science, influence of the curriculum, the classroom environment, the influence of careers, peers and family and self-concept, commonly mentioned in the literature as possible influencing factors.

In New Zealand primary schools, science teachers have the freedom of choice to teach science in a variety of ways through context-based experiences without the constraints of standards-based assessments, credits and test scores. Yet, in many classes’ science may not be delivered as expected due to the lack of science pedagogical content knowledge of the teacher (Appleton, 2003), low subject confidence, lack of resources such as equipment or the apparent low priority given to science over English and mathematics (Appleton & Kindt, 1999). Low engagement in primary science classes can thwart the interest of students even before they proceed to intermediate or high school.

Contrary to this, teachers with a strong science background with a robust knowledge about the nature of science, and who are keen to provide students with practical experiences, can motivate curiosity among the students, providing a highly positive influence. From extensive cross-sectional and longitudinal studies carried out with multi-ethnic elementary students (Asian, Black, Hispanic, White and “Other”) in the USA, Gottfried (1990) has reported that children with higher academic intrinsic motivation in early years are more likely to show greater achievement and higher motivation in later years. Teachers providing challenging learning tasks allow such children to develop mastery in a subject and experience less anxiety as they develop.
The literature reveals that for a large population of students this interest in science is possibly at its peak during Years 9 and 10 at secondary schools (Lyons & Quinn, 2010). Many students who are naturally curious about science may become disengaged from experiences of school science as they proceed from primary to secondary school (Speering, & Rennie, 1996; Barmby, Kind & Jones, 2008). This is endorsed by the fact that select students who are extremely motivated, energized and excited about science during primary or intermediate schooling years experiencing the flow effect (Shernoff, Csikszentmihalyi, Schneider & Shernoff, 2014) lose this concentration, interest and positive effect in senior secondary school.

Students’ interest in science tend to decrease due to several factors in senior secondary classes. These include rushed curriculum, the lack of discussion or practical work and repetition of the content leading to a poor affective outcome (Osborne & Collins, 2001). A transmissive pedagogical approach in classrooms (Lyons, 2006) reiterated by Koul and Fisher’s (2003) accounts of passively receptive students is a major cause of student dissatisfaction and disenchantment with science.

Some students who have shown to have a keen interest in science outside the class are not attracted by the topics offered in the curriculum as there is a lack of authenticity and relevance to their lives (Braund & Reiss, 2006). While students proclaim their interest in science outside of school, many of them do not take science as a learning subject (Jenkins & Nelson, 2005) due to the boring curriculum or content. Difficult content laden subjects like physics also act as a detriment to the process (Osborne & Collins, 2001). In England and Wales, the falling numbers of enrolments especially in physics is well documented between 1990 to 2000 in the secondary A level examinations in studies by Osborne, Simon and Collins (2003).

Culturally relevant pedagogy, which has been identified as a mechanism for engaging various ethnic groups (Patchen & Cox-Petersen, 2008; Wee & Lun, 2014) is often lacking in classrooms. This can marginalise students from specific cultures or ethnicities from pursuing science; because teaching and learning science fails to connect with their values outside the classroom. An unengaging curriculum (Lyons, 2006), a negative attitude towards school science (Osborne, Simon & Collins, 2003) along with gender preferences for science subjects where boys are more inclined towards science than girls (Schibeci, 1984; Breakwell & Beardsell, 2016) are other factors that provide mounting evidence for the decline in interest in science. Schreiner & Sjoberg (2004) have provided relevant international data from their survey regarding the significant decline in student interest in science, especially among females from the Relevance of Science Education (ROSE) project administered in over 20 countries. For many of these students the curriculum did not reflect their personal interests in
science. The stereotypical images of scientists portrayed in the media and cartoons as *crazy people* has also deterred youngsters from taking science (Sjøberg, 2003). There also remained the chasm between the cultural worlds of students and the cultural world of science (Aikenhead, 1996).

Contrary to the negative attitudes and factors mentioned previously, it is also observed that some students who are not interested in science continue to participate in science subjects. These students are strongly influenced by their own personality, career pathways and strong influence of family members (Breakwell & Beardsell, 2016; Schnabel, Alfeld, Eccles, Koller & Baumert, 2002). Bull, Brooking and Campbell (2008) postulate that successful home-school partnerships can also have a strong positive influence on students’ learning, engagement and achievement in continuing with science despite personal disinterest.

Students at the age of 17 to 18 years are at an important stage in their lives where they are provided with many potential career opportunities. No longer are people bound to a single linear job as jobs for life have been replaced by life-long learning. Urbanization, geographic mobility, cultural diversity, technological advances and the desire to succeed in the present economy are various factors that influence an adolescent’s thinking processes (National Research Council USA, NRC, 1999). Thus, decision processes influence strategic decision-making effectiveness.

To summarise, there exists a multitude of factors that can impact on students’ decision making. Commonly, interaction of various environmental factors (Costa, 1995; Osborne, Driver & Simon, 1998; Jones, Howe & Rua, 2000) as well as an individual’s intrinsic motivation (Gottfried, 1990) affect these processes. Detailed brain studies using neuroimaging techniques have also revealed that several cognitive processes (Dietrich & Kanso, 2010) constitute to decision making, creativity and critical thinking. Decision making is not always a linear process. Interaction of several factors detailed by Hipkins and Bolstad, (2005); Hipkins, Roberts, Bolstad and Ferral, (2006) juxtaposed during the secondary schooling years are believed to contribute towards either positive or negative attitudes to various disciplines as discussed earlier. These attitudes in turn manifest as influences on an individual’s cognitive behaviour and inspire decision making.

### 2.5.1 Attitudes to science

Attitudes to science, including the affective domain play an essential role in decision making (Francis & Greer, 1999). The term attitude as defined by Kind, Jones & Barmby, (2007, p.4) include
“… the feelings that a person has about an object, based on their beliefs about that object. Attitude towards science can be viewed as a way of mapping students’ cognitive and emotional opinions about the various aspects of science.”

Osborne, Simon & Collins (2003, p.1054) incorporate a range of components or sub-constructs from several researchers to define these attitudes. They include:

- perception of the science teacher
- anxiety toward science
- the value of science
- self-esteem at science
- motivation towards science
- enjoyment of science
- attitudes of peers and friends towards science
- attitudes of parents towards science
- the nature of the classroom environment
- achievement in science or the fear of failure as a part of the main attitude construct.

These attitudes can affect learning and either engage or disengage students’ interests in specific subjects. For example, physics and chemistry were found to be the least popular subjects in comparison to biology (Whitfield, 1971; Ormerod and Duckworth, 1975; Havard, 1996; Osborne and Collins, 2000 in Osborne, Simon & Collins, 2003) among post 14-year olds with regards to subject preferences.

Some of the above sub-constructs of attitude, including classroom environment, the science curriculum, influence of parents and career options used in the survey and interviews relevant to this study are further discussed in the following sections.

2.5.2 The classroom environment
This consists of multiple variables that can profoundly affect the learning process impacting the attitudes of a learner. These variables include the influence of the teacher, peer interaction, pedagogical methods, science experiences such as laboratory experiments and activities in and out of the classroom. They all play a pivotal role in influencing an individual’s learning through the primary, intermediate and secondary school years, and, thus evolves the science attitudes, positive for some, negative for some and ambivalent for others.

Historically, individual teachers and pedagogical methods have always had an impact on students. Haladyna, Olsen & Shaughnessy (1982) pointed out the positive impact of the
relationships between the teacher and the students, along with variables such as quality of the teacher, support, praise and commitment from the teacher, as significant determinants of positive attitude development among students. Those teachers who have difficulties in designing specific strategies to interest the learner or are caught up in the need to complete the syllabus tend to disengage and disinterest learners.

Myers and Fouts (1992) in their cluster analysis of 27 schools in the USA, explored the classroom environment and have stated that learning environment variables are important predictors of developing attitudes in science. For example, when classes in physics, chemistry and biology were taught by teachers in their specific field of preparation, student achievement levels were high, showing a strong correlation between teacher and student’s positive attitudes to science (Myers & Fouts, 1992).

Positive reports such as those from teachers using Process Oriented Guided Inquiry Learning (POGIL) especially in organic chemistry (Hein, 2012) in the USA, provide substantial evidence to show that students have a better grasp of concepts and knowledge in content laden subjects like chemistry and biology. Pedagogical techniques used by POGIL trained teachers in biology, chemistry and other science classes, facilitate collaborative and cooperative learning among students, and enhance higher order thinking skills.

Similarly, activities from carefully sequenced courses of Project Lead the Way (PLTW) in the USA have allowed secondary science students to develop both knowledge and skills in various sciences integrating maths and engineering through diverse projects and learning activities based on real world problems (Dare, 2006). These students are successful in following a vocational pathway into engineering, biotechnology and biochemistry. This integrated programme has been successfully used in over 6500 elementary, middle and secondary schools in the USA to date.

Stohlmann, Moore and Roehrig (2012) provide further evidence from their study of an integrated PLTW programme run in large suburban middle school in a Midwestern state in the USA. All students at this school between 6th to the 8th grade was enrolled in the PLTW programme. They were taught science through an integrated approach along with technology and mathematics by four teachers, each an expert in a field who team taught the classes with a focus on a student-centred approach. During their observations of these PLTW enrolled students Stohlmann, Moore and Roehrig (2012) reported the thoughtful engagement of students in designing and building dragsters as well as the Rube Goldberg machine using 3-D
modelling software. Retaining this high level of interest by the teachers was the key to student success.

However, not all schools can afford the POGIL or PLTW programme due to the high costs of consumables, the pre-prepared resources and the extensive training required by teachers to implement these programmes. Inequity in finances and resources often thwarts the delivery of high-quality education.

The classroom environment’s indirect effect on influencing student choices in the later secondary years is, to a large extent, influenced by diverse teaching styles. Woolnough (1994, 1996) describes how effective stimulus activities provided by teachers stimulate student curiosity and imagination improving attitudes towards science. Illustrations include developing conceptual understanding through argument, such as the use of socio-scientific issues in decision making or developing investigational capability through inquiry-based education and experiments. (Driver, Newton & Osborne, 2000; Kolsto, 2001). These ideas are further strengthened by the commentary from the 2015 PISA results in the OECD report (2018). It suggests how both school leaders and the governments must take responsibility and enable science teaching to be more effective. There is an onus on the government to provide effective professional development to encourage success in science.

While a negative classroom environment plays a major role in impacting negative attitudes among students, it is important to note that a select group of students will pursue science irrespective of external factors. Individuals who are highly motivated either by career options, social status and solid family support (Cleaves, 2005; Lyons, 2006) will follow a science trajectory regardless of perceived difficulty level of the subject, poor quality teaching or the unengaging science curriculum. Similarly, students with high intrinsic motivation (Gottfried, 1990), strong self-determination (Ryan and Deci, 2000,) and an expansive growth mindset (Claro, Paunesku & Dweck, 2016) continue with certain subjects irrespective of all odds.

Apart from the curriculum delivery, a content laden curriculum can disengage many students. While teachers influence student attitude, the curriculum itself also has an impact. The implications of a tedious curriculum and its disaffection for declining student numbers is discussed in the next section.

### 2.5.3 The science curriculum

The science curriculum has been unattractive and labelled as being *boring and irrelevant* in several studies carried out in Australian secondary schools by Lyons, (2006). In a Swedish longitudinal study Lindahl (2003) examined the changes in the pupils’ attitudes and interests
in science during the last five years in compulsory school (age 12 to 16 years) and the subject choices made in upper secondary school (17 to 18 years). Findings indicated a steady decline in interest in science subjects with increasing age. This was attributed to the difficulty of the content, authoritarian nature of subjects like physics and chemistry and the lack of comprehension of abstract concepts in science, heightened by transmissive pedagogy. The focus of a packed curriculum completed within strict time frames to meet the needs of examination regimes is another major factor that deters students from continuing with science (Osborne & Collins, 2001; Koul & Fisher, 2003; Hart, 2002).

A study in England in 2005 (Jenkins & Nelson) using the Relevance of Science Education Project (ROSE) questionnaire with 14 and 15-year olds ($N=1277$) designed by Sjoberg and Schreiner (2010) reported that science was less popular than other school subjects as it did not enthuse the students. While the general feeling was that science was an important subject, it did not resonate personally for individuals to continue studying science during the later years of schooling gearing towards a career (Jenkins & Nelson, 2005).

In an extensive study carried out with 437 sixth graders in the USA, Jones, Howe and Rua, (2000) reported that science was regarded as a difficult subject, especially by girls, and physics particularly was deemed the most difficult of the traditional science subjects by both boys and girls. While both boys and girls expressed an interest in science, the variety of experiences leading to greater interests in the physical sciences came through with the boys. This was related to out of school activities that the boys had experienced such as tinkering with electric toy cars, batteries and fuses (Jones, Howe & Rua, 2000).

There is also a growing concern in New Zealand by several educators who wonder whether the NCEA achievement standards have effectively become the curriculum for most senior students (Middleton, 2018). The replacement of NZ Bursary examinations by NCEA was largely to ensure that NCEA would provide an enriching and progressive curriculum with engaging pedagogical practices towards achievement (Middleton, 2018). However, these intentions come under scrutiny because of assessment practices. There are suggestions for changes. These have been recently published for public consultation in an extensive report by Tomorrows’ School independent taskforce (Ministry of Education, 2018).

Regardless of the crowded curriculum and difficulty levels of traditional science subjects, the influence of parents’ aspirations for their children to succeed in education is an accepted fact. Even though schools today are equipped with deans, careers and academic counsellors who guide students about making subject choices, much of the literature points to parental and
family influences in students’ decision making that may either overrule or strongly support an individual’s choices for the future. The role of the such external influences are discussed in the next section.

2.5.4 The influence of family, peers and career counsellors
Family, peers and career counsellors have always been notable factors affecting educational and career decision making in varying degrees among adolescents. Key factors like the number of counsellors available at schools, the time spent by a student with the counsellor and the quality of information received have significant impact on students. Diverse career counselling practices in a few schools that provide students specific information about the myriad of science related jobs, of which, they may not have been aware is a possible relevant factor that enables students to opt for science pathways (Taskinen, Schutte & Prenzel, 2013). New Zealand research (Hipkins, Roberts, Bolstad & Ferral, 2006) suggests that students who received sound advice from career advisors regarding tertiary studies and career pathways based on their personal interests and achievements were positive about their subject choice decisions. Previous research has also shown that students speak about their career aspirations with both counsellors and parents (Otto, 2000).

While both father and mother can be involved with children’s vocational aspirations and expectations, the greater role of the mother in understanding and influencing adolescents’ career interests and abilities has been strongly acknowledged (Otto, 2000). These findings (Otto, 2000) were reported from a cross-sectional group of students (N= 371), from two schools in North Carolina, enrolled in required courses. Survey data indicated that the youth were talking more seriously about their training or educational needs for the future with their mothers (74%), than friends (57%), fathers (52%) and counsellors (48%). Paa and McWhirter’s (2000) descriptive studies mentions less peer influence on adolescents but contrary to Otto (2000) they have cited corresponding same sex parent influences on adolescents to be stronger. According to Paa and McWhirter (2000), boys were more influenced by their fathers and girls by their mothers in their aspirations to career pathways. From a longitudinal study in Australia, Lyons (2004) has reiterated the influence of “family worlds” in guiding students in choosing subjects notably physics. Parents with formal education and a positive attitude towards science encouraged their children to choose physics because of the focus of a “strategic value” in the future. Whiston and Keller (2004) lay emphasis that family structure variables such as the parents’ own occupation and family
process variables which include support, attachment and autonomy, interact together to influence adolescents various career constructs, starting with the choices about education and subject pathways right from secondary school to tertiary education. Breakwell and Beardsell, (2016) and other researchers including Hargrove, Creagh, and Burgess, (2002), have argued that despite the correlation between family contexts influencing career development, more research is required to view numerous constructs related to the family to be able to establish a complete link between the two.

Some researchers have postulated that parental influence in some cultures may affect students’ decision making in definite ways (Han, Leichtman & Wang, 1998; Leichtman, Wang, Pillemer, 2003). According to Leichtman, Wang, Pillemer, (2003), parental influence on children is more visible in certain cultures like Korea, China, India, Western Europe and the United States. While Asian families are more academically involved and foster interdependence, Caucasian families are more emotionally involved and foster independence with their parenting styles (Leichtman, Wang & Pillemer, 2003). In their executive summary of their seminal work towards the Best Evidence Synthesis Biddulph and Biddulph and Biddulph (2003) discuss how ethnicity and culture link to students’ academic achievement. They state that Pakeha and Asian children have consistently produced better results than Māori and Pasifika children. Early studies by Kelly (1988) have also shown the influence of ethnicity on subject choices. Asian boys were more likely to take science and achieve higher results than Black or White students especially in the physical sciences, by the time they were in their fifth year in similar background secondary schools in Britain. This is further echoed and reiterated by results from longitudinal studies conducted during the seminal ASPIRES project by DeWitt, Archer, Osborne, Dillion, Willis &Wong (2011). They have also reported on the high aspirations of the “Asian” students’ entry into science subjects. Their results specifically refer to the success of Asian students of Chinese and Indian descent over other “Asian” ethnicities like Pakistani and Bangladeshi as well as Black or White students, the reason being high parental expectation and influence of parents in their academic choices.

Such parenting styles have their own positive effects in each cultural context. Schultheiss, Kress, Manzi, and Glasscock (2001) have also recommended that factors including socioeconomic status, racial/ethnic background and family structure must be examined to identify the role of family relationships on the effect of career development. A longitudinal case study by Archer, Dewitt and Osborne (2015) that collected interview data from Black African/Caribbean students (n=10) and their parents, tracking students from ages 10 to 14 years in the UK also described how lack of the cultural capital of the parents could hinder, or
in some cases enhance students’ aspirations, into following science and science careers. While family influence is a strong factor in decision making, the role of careers is another major feature that is explored next.

2.5.5 Careers for the future

Career aspirations often dictate the choice pattern of subjects in secondary schools. This is because subject choices form the pipeline towards tertiary education or/and the work force for many students who follow “trajectories” leading to target careers (Cleaves, 2005). Cleaves (2005) states that students who are ambitious to pursue high visibility jobs” such as medicine, sports and teaching, often follow a “directed trajectory” and have a clear career commitment early in their secondary schooling years. They will pursue specific science subjects, irrespective of all constraints. Those with less focussed career direction may follow “partially resolved trajectories” or multiple projection trajectories” and take science more to keep options open.

Though decision making may often be coloured by past experiences (Furlong, 2005) of disengaging activities, packed curriculum and transmissive pedagogy, the final years of schooling requires students to identify requirements for the future. The Australian study by Lyons (2006) examining enrolment decisions for choosing physical science courses in tertiary studies indicated that, despite poor science teaching methods in schools, students continued with this subject as they were influenced by other variables including sociocultural factors and prospective careers. According to Lyons, (2006) aspects such as the gender of the student, high achieving abilities, ethnic influence-especially for students from South East Asian backgrounds and affluent families- seem to have a definitive role in this decision making. This is supported by Hipkins, Roberts, Bolstad & Ferral (2006) who state that even though students found science teaching to be boring, some students still pursued science at the tertiary level as they were self-motivated and had career options in mind.

Apart from the various factors mentioned, self-motivation, self-efficacy and self-determination can highly impact subject selection. Glynn, Brickman, Armstrong & Taasoobshirazi, (2011) emphasize that self-determination underpins all the above factors.

From the literature there are two theories, namely, self-determination theory and self-concept theory that underpin the factors that influence decision making. Each of these theories are discussed in turn with respect to student choice of subjects.
2.6 Self-determination theory and its influence on decision making

Self Determination Theory (SDT) is an approach in psychology that provides the framework to understand how motivation is developed in individuals. It is a macro theory of human motivation. The choices people make based on their own motivation emanating from personal psychological needs forms the foundation of this theory. Hidi and Renninger (2006) believe that affective and cognitive components of interests have a profound effect on an individual’s learning. This accounts for intrinsic motivation as an important factor in decision making. This explains why students taking science irrespective of all odds follow “trajectories” (Cleaves, 2006) as they are highly driven.

Ryan and Deci (2000) discuss how people can be proactive and motivated or be detached and distanced, as a component of social conditions and the environment in which they live and work. This motivation to remain engaged can be intrinsic or extrinsic. They further distinguish and define intrinsic motivation as the “doing of an activity for its inherent satisfaction rather than for some separable consequence. It is the inherent tendency to seek out novelty and challenges to extend and exercise one’s capacities, to explore and to learn.” (Ryan & Deci, 2000, p, 70), while, extrinsic motivation refers to “the performance of an activity in order to attain some separable outcome.” Intrinsic motivation plays a very important role in educational settings and has a far-reaching impact on student decision making.

Considering the merits of this idea, the benefit to students with a high propensity to pursue science because of intrinsic motivation is that it provides them with tools to be able to question and explore the world around them and pursue their curiosity. However, in secondary schools the influence of both family and the school environment can either facilitate or thwart one or more of the three human qualities of competence, autonomy and relatedness and play a major role in enhancing or crushing the intrinsic motivation to pursue science.

Self-determination theory plays a vital role in understanding how motivation influences the way individuals make their choices according to their psychological needs (Deci, Vallerand, Pelletier & Ryan, 1991). Like SDT, self-concept is another psychological construct that impacts various aspects of decision making.

2.7 Self-concept and its impact on decision making

Self-concept, broadly defined, is a “person's perceptions of themselves. These perceptions are formed through one's experience with and interpretations of one's environment and are influenced especially by reinforcements, evaluations by significant others, and one's
attributions for one's own behaviour” (Shavelson et al., 1976 in Shavelson & Bolus, 1982, p.3).

This self-concept can further be viewed as academic self-concept relating to specific subjects in school/college or non-academic self-concept that relates to social, emotional and physical aspects of oneself (Shavelson & Bolus, 1982). The construct of self-concept is multidimensional and situational given the various environments that one is placed in at different stages in life. From their longitudinal and cross-sectional study with (N=385) French-Canadian elementary school children, Guay, Marsh, and Boivin, (2003) examine the developmental trends between academic self-concept and academic achievement. Analyses from their studies surmised a reciprocal effect between the two. Further, academic self-concept increases with age and is more reliable and stable becoming interrelated with academic achievement.

The self-concept construct also has a descriptive and an evaluative dimension (Shavelson & Bolus, 1982; Bong & Skaalvik, 2003) to it. For example, a student may describe themselves as being confident in science because science work in class is easy or they describe the feeling of success as they score good grades on assessments or conversely the opposite happens with poor results. According to Bong and Skaalvik (2003) the self-belief of these perceptions has a substantial impact on the affective domain with further implications for intrinsic motivation. As academic self-concept develops based on past experience over time, it can have a totally positive or negative impact on decision making. Creating positive learning environments and providing the best experiences in science classrooms enhances a positive self-concept of science in students.

2.8 Conclusion

This chapter has provided an overview of why science is important for all students. It has pointed out the specific purposes of teaching science to all students with an emphasis on developing skills in the wake of current technological changes and the need for a STEM workforce. While an array of alternative science related subjects is being offered at various schools globally, there is a gradual decrease in traditional science subjects and reasons for this decrease have been outlined. The fact that students are opting for related subjects like home economics, psychology, business studies, economics, theatre and sport studies that contain aspects of science and are yet not regarded as science may further skew research data on science options (Osborne Simon, & Collins, 2003).
The justification to pursue the research comes from the fact that as a secondary school science teacher I am faced with the challenge of knowing how to steer students into science classes. What can we do as facilitators to boost the declining numbers in science classes particularly in low decile schools that have higher percentage of Māori and Pasifika student’s enrolment but a low representation in high school science?

There is a strong desire to understand from student voices the reasons for this decline. While small scale studies on science option choices made by New Zealand students are available there exists a gap in the national data fully researched and available for all New Zealand secondary schools. The primacy of the research questions outlined in the previous chapter has made it clear that understanding student voices from the stakeholders themselves would constitute an important source to comprehend such decision-making (Adey & Biddulph, 2001; Cook-Sather, 2002, 2006; Jenkins, 2006) and thus forms the foundation of this study.
Chapter Three: Methodology

3.1 Introduction
The aim of this research study was to investigate students’ perceptions regarding the factors that influenced their subject choices, specifically science and non-science selections in Year 13. As discussed in Chapter two, the literature establishes that there is a growing concern of declining enrolment numbers in secondary science globally. There is an interplay of several factors including students’ personal and family worlds, career pathways, experiences of school science, the science curriculum, self-determination to name a few, in subject choice decision-making (Cleaves, 2005; Lyons, 2006; Hipkins, Roberts, Bolstad & Ferral, 2006; Lyons & Quinn, 2010). In their seminal article Staying in Science, Hipkins and Bolstad (2005) also emphasise that an interaction between students’ psychological and social factors govern decision making.

This research used an educational context that provides both a natural setting and a strong social science research focus (Punch, 2013) to this study. To gain a clearer understanding of the issue in New Zealand secondary schools, the researcher adopted a mixed-methods approach to this study and recruited participants, both boys and girls from a Year 13 cohort comprising of 300+ students from the participating school in Auckland. The social science theoretical focus (Punch, 2013) was further strengthened as the researcher was trying to piece together a considerable amount of valid information working directly with students and analysing students’ voices from a large group of diverse students to comprehend their behaviour regarding decision making.

This chapter outlines the methodology and research design underpinning the study. In section 3.2 the rationale for the use of social science research approach is discussed. In section 3.3, the pragmatic paradigm underpinning the mixed methods approach is explained including the sampling methods and instruments used followed by an explanation of the research design in section 3.4. Section 3.5 describes the selection of the school with Section 3.6 describing the school setting. Section 3.7 describes the selection of the students. 3.8 details the ethical considerations. Section 3.9 explains the pilot study. Section 3.10 details the data analysis. Section 3.11 explains the trustworthiness and validity of the research study. Finally, section 3.12 summaries the chapter.
3.2 Social Science Research

One of the purposes of social science research is to “explore social reality, understand human behaviour and action, offer a basis for a critique of social reality and suggest possible solutions to social problems.” (Sarantakos, 2012, p.11). New Zealand urban schools, such as those in Auckland for example, exhibit vast diversity among the student population in terms of ethnicity, culture and languages spoken. While some students are monolingual, many are bilingual or even multilingual. The cultural capital that these students bring to the schools is highly varied but not always valued (Bishop & Berryman, 2006). A social science research approach, being diverse and pluralistic (Sarantakos, 2012) was most relevant to this study as it examined the views of a wide-ranging cohort of students in their final year of schooling in an educational social context.

From a social research perspective, ontology is defined as a theory of the nature of social entities (Bryman, 2016, p.696). Objectivism, as perceived in social research takes a stance that “asserts that social phenomena and their meanings have an existence that is independent of social factors” while “constructivism asserts that social phenomena and their meanings are continuously being accomplished by social actors.” (Bryman, 2016, p.692, 696).

With the above understanding in mind, the researcher wished to explore the ontological beliefs from diverse students’ perspectives about the nature of reality (Punch, 2013) specifically regarding the apathy towards science options. The ontological question: What is the form and nature of reality (Punch, 2013) regarding the need and importance of science as an option subject in students’ lives was to be objectively analysed from students’ perspectives, their views and personal opinions using research data. The researcher wished to understand the fundamental categories of reality experienced by the students in their own worlds and described in their individual words (Punch, 2013. Neuman, 2013).

A social-constructivist epistemological approach (Hammond & Wellington, 2012; Punch, 2013) was used by the researcher to appreciate how knowledge is construed by the various participants used in this study towards decision making. This is because human development and knowledge is believed to be constructed through interaction with others in a social setting (Punch, 2013). A pragmatic paradigm that could use and reflect on both objective and subjective evidence thus formed the principle framework for the study.

3.3 The pragmatic paradigm

The philosophy underpinning this study was based on the foundation of a pragmatic paradigm.
Educational research is the structured systematic application of a family of methods that are employed to provide trustworthy information about educational problems (Mertens, 2014). The researcher used the theoretical lens of pragmatism (Tashakkori & Teddlie, 2010, Creswell & Clark, 2017) to analyse the data. Pragmatism is couched in social science research and therefore aligned well with this study. A paradigm as defined by Newman (2013, p.94) is “a general organising framework for theory and research that includes basic assumptions, key issues, models of quality research and methods for seeking answers.” A paradigm guides the ontology, epistemology and the methodology in a research study. The key questions to this research study arose directly from personal observations of the researcher, a practitioner, who observed a decline in science enrolments in traditional science subjects in senior secondary classes over the past six years in her school. The concern was strengthened from the literature and international reports like the TIMMS (2014/2015) and PISA information. To find answers and possible solutions to these concerns a pragmatic approach was adopted. The key questions that guided the research were:

- Why do students select science in secondary schools?
- Why do students refrain from selecting science in secondary schools?
- What attitudes do students hold towards science?
- What factors interplay and influence this decision making?

Pragmatists have been described by Creswell (2009) as real-world practice oriented, problem centred, and pluralistic individuals who focus more on research problems than on methods by The philosophical roots of pragmatism can be found in the very early studies of James (1904) and Dewey (1930) who believed that pragmatists were known to take a practical approach since practice and theory were entwined. The early pragmatists believed that theory emerged from practice and could then be applied back to practice.

A pragmatist includes axiological beliefs of their personal view, ethics and values along with the participants views and values from multiple realities to draw conclusions about their experiences and understanding of reality (Maxey, 2003). This is further supported by Soiferman (2010), who believes that reality is understood through using many tools of research that reflect both deductive (objective) evidence and inductive (subjective) evidence. These evidences could lead to an abductive reasoning where initial incomplete observations or evidences may further provide a likely explanation if all data are combined from various sources (Soiferman, 2010).
In this study the researcher wished to analyse if there exists some coherence and logic in students’ responses towards decision making about subject choices. The researcher was also keen to recognize if there is commonality between the participants’ opinions, such as the existence of a definite interplay of explicit factors in this process of decision making. To draw conclusions from these findings, that could be relevant in the future to practitioners and students, a pluralistic pragmatic view was paramount. The researcher decided to apply two types of social research strategies, quantitative and qualitative approaches to gather information to obtain findings. This led to the use of a mixed methods design (Tashakkori & Teddlie, 2010, Creswell & Clark, 2017) described below.

3.4 The research design

The research design used a case-study in one low decile school following a mixed methods approach. Mixed methods design as defined by Tashakkori and Teddlie (2010, ) is: “a type of research design in which QUAL (qualitative) and QUAN (quantitative) approaches are used in the type of questions, research methods, data collection and analysis procedures, and/or inferences.” (p.711) Since the study was designed to be carried out in two distinct phases, the researcher collected, and analysed quantitative data during Phase 1 and qualitative data during Phase 2 (Creswell & Clark, 2017). These are further explained in detail in sections 3.4.1 and 3.4.2.

During Phase 1, a survey was used to study all consenting participants (N=102) in Year 13 from both science and non-science enrolments. In Phase 2, a small group of consenting participants from Phase 1 were recruited (n=10) to take part in interviews. These participants provided descriptive data via semi-structured interviews. The quantitative data provided statistical information and was evaluated objectively. The qualitative data was further expected to provide rich descriptive information adding more precision to the statistical data via the narratives (Greene, 2017).

Crimmins (2017, p.95) believes that “in humanistic research qualitative research adds flesh to the bones of quantitative data.” Such views were also voiced by early researchers such as Jick (1979) who strongly proposed the use of both quantitative and qualitative methods as it provides a sound basis and depth for triangulation and evaluating convergence. Additionally, the combined strengths of the two methods overshadow the weakness of each individual method and facilitates a deeper understanding of the phenomenon under study (Johnson & Onwuegbuzie, 2004). Current trends in using mixed methods approach is further reinforced by

A visual model for the mixed methods sequential explanatory design procedure adapted from Ivankova and Stick, (2007) is illustrated in table 1.

*Table 1 Model for Mixed Methods Sequential Explanatory Design*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Procedure</th>
<th>Product</th>
</tr>
</thead>
<tbody>
<tr>
<td>QUANTITATIVE</td>
<td>*Web-based survey (N=102) using a 25 items questionnaire with a 6-point Likert scale</td>
<td>*Numeric Data</td>
</tr>
<tr>
<td>Data Collection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>QUANTITATIVE</td>
<td>*Data screening</td>
<td>*Descriptive statistics</td>
</tr>
<tr>
<td></td>
<td>*Use of Qualtrics software for filters</td>
<td>*Tabulation with numbers</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>*Email individuals for interviews</td>
<td>*Communication for setting up an interview for phase 2</td>
</tr>
<tr>
<td>Interview, Protocol</td>
<td>*Developing interview questions</td>
<td>*Case (n=10)</td>
</tr>
<tr>
<td>Development</td>
<td>*Stratified exampling technique</td>
<td>*Interview protocol</td>
</tr>
<tr>
<td>Qualitative</td>
<td>*Selecting participants (n=10) from different ethnic groups.</td>
<td></td>
</tr>
<tr>
<td>Data Collection</td>
<td>*Simple Random Sampling method after stratification</td>
<td></td>
</tr>
<tr>
<td>Qualitative</td>
<td>*Individual in-depth face to face interview with 10 participants</td>
<td>*text data from interviews</td>
</tr>
<tr>
<td>Data Analysis</td>
<td>*Use of prompts to elicit information</td>
<td>*Narratives from transcripts</td>
</tr>
<tr>
<td>INTEGRATION of Quantitative and Qualitative Results</td>
<td>*Coding and thematic analysis *Cross thematic analysis</td>
<td>*Coding and themes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*Similar and different themes and categories</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*Advantages and disadvantages</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*Discussion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*Implications</td>
</tr>
<tr>
<td></td>
<td></td>
<td>*Future research</td>
</tr>
</tbody>
</table>

Adapted from Ivankova and Stick (2007)
The rationale to support the use of a mixed methods research design in this study is further justified by the observations of Ivankova and Stick, (2007) who suggest that in social science contexts such as an educational set-up, a mixed methods approach, that uses data from both quantitative and qualitative methods provides a more complete and more holistic picture to answer the research questions. This is because the two sets of data can be amalgamated from both approaches. Neither the quantitative method nor qualitative method on its own is sufficient to capture the trends or portray a complete picture of a complex issue involving multivariate data (Ivankova & Stick, 2007). Mixing both types of data, delivers an all-inclusive insight to the research questions based on the data analysis and findings. Ivankova, Creswell and Stick (2006) further elaborate that a more robust analysis of the data is made possible as the quantitative and qualitative methods complement each other. These views have been validated and substantiated earlier by several researchers including Greene, Caracelli, and Graham 1989; Caracelli and Greene 1993, 1997; Tashakkori and Teddlie 1998, 2003; Miles and Huberman 2002).

Furthermore, Johnson & Onwuegbuzie (2004) propose that pragmatists can look at both numbers (quantitative) and narratives (qualitative) distinctly alongside each other in research as each gives significant meaning to the other. This leads to pragmatists being open to both quantitative and qualitative data in understanding problems and finding solutions in the social science for example education (Johnson & Onwuegbuzie (2004). Since researchers collect both closed data and open-ended data in conjunction, analyse them rigorously and provide a complete picture of the given problem it provides a better awareness of the research problem. (Creswell & Creswell, 2017).

A sequential explanatory approach (Tashakkori and Teddlie, 2003; Creswell, 2009; Creswell & Clark, 2017) was used in this study. The first step involved designing and implementing the quantitative strand using a survey. Strategies from this step were then employed to connect the quantitative results from the survey to designing and implementing interviews during the qualitative phase. The combining of the two strategies in tandem within the single study, led to a mixed method design incorporating the sequential explanatory approach (Creswell, 2009, Creswell & Clark, 2017, Tashakkori & Teddlie, 2008) above.

The justification for the sequential explanatory approach can be understood from the steps followed by the researcher in this study.
• During Step 1, a quantitative approach was used to gather statistical data from the sample population (N=102) using a survey (see Appendix 1). This sample population was a subset of a total population of 300+ Year 13 students who had agreed to participate in the study. The methods of data collection are detailed in the next section.

• In Step 2 the researcher analysed the statistical data from Step 1. The statistical analysis provided a foundation that outlined similarities and differences between the results of science and non-science students within various constructs. Both significant and nonsignificant results, group differences and other outliers (Creswell & Clark, 2017) could then be used to draw narratives during the interviews to probe into the phenomena of making choices.

• In Step 3 the researcher used a stratified sampling technique to recruit a small meaningful sample (n=10) to gather qualitative data from the initial pool of the participating population (N=102). The key focus was to include the opinions of diverse students inclusive of gender differences, variance in the disciplines that they had selected in Year 13 as well as the different ethnicities representative of the total population of the school. The qualitative data could further explain the quantitative results.

• In Step 4, the researcher collected narratives and descriptive open-ended data with protocols informed by the quantitative results (Creswell & Clark, 2017) using a qualitative approach. An interview guide was used during the semi-structured interviews (see Appendix 2).

• Step 5 led to coding the large amount of data from the respondents and organising them into various emerging themes. This is discussed at length in the thematic analysis, a method commonly used in gathering and analysing qualitative data (Braun & Clarke, 2014) in section 3.4.2.

• Step 6 involved reporting on the findings of the quantitative data and qualitative data individually before amalgamating the findings from both sets of data, by integrating, analysing and then writing a comprehensive report using for confirming and disconfirming evidence.

3.5 Methods in research. Instruments used in Phase 1 and Phase 2.

3.5.1 Phase 1 – Survey

Research methods are employed to gather data and analyse the same within a research study. During Phase 1 of the study an online survey (Appendix 1) was the instrument developed to
collect the primary data from the sample population of students (N=102) who had consented to take part in the survey. The survey developed in this study was adapted using constructs from both surveys and questionnaires such as the Relevance of Science Education (ROSE) project used in several countries around the world (Sjøberg & Schreiner, 2010) and from both surveys and questionnaires designed by Cheung, (2018), Barnby, Kind and Jones, (2008), Pell and Jarvis, (2001) and Francis and Greer, (1999).

Respondents were introduced to the researcher via a detailed student Participation Information Sheet (PIF- Appendix - 3) along with the student Consent Form (CF- Appendix 4).

The purpose of using a survey initially to collect quantitative data, was to help explore the spread of opinion among several members of the population (Hammond & Wellington, 2012). According to Creswell and Clark (2017) survey designs using surveys or questionnaires provide a quantitative or numeric description of trends, opinions and attitudes of a population by being able to reflect the attributes of a large population from a small group of individuals surveyed. This is further endorsed by Fowler, (2013) who says that it is vital to include all attributes in the items of the survey to be able to measure the attitudes of the respondents. This view is strengthened by Brace (2018) who opines that irrespective of different scales that are used, the crucial factor is to ensure that the wordings of the specific items against which the attitudes are to be measured is done correctly so that respondents understand what they are being asked.

The survey as mentioned earlier was classified into 2 parts. Part A collected data using extraneous variables that included the students’ demographics, their gender, subjects selected at Year 13 and languages spoken at home. These were used to make statistical inferences in the discussions relating to various constructs, including the attitudes of science and non-science respondents towards general attitudes and opinions about science and science related careers.

Part B of the survey included 25 statements, which were listed under 5 specifically coded constructs (Wisker, 2007; Creswell 2009). These 25 items were used to collect multivariate data as several variables were involved. This kind of data is also referred to as categorical or nominal data (Agresti & Kateri, 2011). This is because the 25 statements in the survey had no natural ordering (Agresti & Kateri, 2011). One of the reasons that it is a popularly used method for survey questions is because of the ease of analysis. Specific labels were used in collecting data under each construct or category. Each construct had 5 related statements. The labels assigned to the five main constructs included:
- Individual interest in science
- External influences
- Science self-concept
- Situational influences in the science classroom
- Career and employment prospects.

The Likert scale for each question had 6 choices. These included:

- Strongly Agree
- Agree
- Slightly Agree
- Slightly Disagree
- Disagree
- Strongly Disagree

Each construct had inter-related questions suitable to the construct. These questions were adapted from previously used surveys/questionnaires that had been trialled in research work and displayed a high Cronbach’s alpha value based on statistical factor analysis (O’ Rourke, Psych & Hatcher, 2013). Cronbach’s alpha is the coefficient of reliability that provides a measure of internal consistency of the items within a construct, that is, how closely related a set of items are as a group or category (Barmby, Kind & Jones, 2008). This allowed for the survey to be reliable. Questions used by different researchers were similar in many respects as the authors had used similar constructs and meta constructs in their individual research studies (Cheung, 2018; Barmby, Kind & Jones, 2008; Pell and Jarvis, 2001; and Francis & Greer, 1999).

A Likert scale, a commonly used psychometric scale used to gauge people’s attitudes to various topics was used in the questionnaire. The Likert scale was first published in 1932 by Rensis Likert and is commonly referred to as the “agree-disagree” scale (Brace, 2018). The intention of using the Likert scale was that the statements would represent different aspects of the same attitude (Brace, 2018). A further application of the Likert scale was to sum up the scores for the five statements under each category and provide an overall attitudinal score for each category (Brace, 2018). The researcher then summarised the proportion of the population that chose each category using percentages using the Excel programme.

Respondents are typically provided with several attitude dimensions, for each of these statements they are required to respond to either an even (6 point) or odd number (5 point)
scale (Brace, 2018). The Likert scale in this survey included a 6-point scale with choices ranging from 1 to 6, (strongly agree, agree, slightly agree, slightly disagree, disagree and strongly disagree). A Likert scale provides a greater nuance than binary scales to elicit opinions from the participants than from simple binary yes/no responses. The reason for using a six-point versus a five-point scale was to reduce the opportunity of choice for participants towards answering the moderate value or middle point value without considering all items of measurement in the proposition (Chomeya, 2010). Six-point scales also minimise social desirability bias as pointed out by Garland (1991) as respondents tend to select a mid-point value to please the interviewer. Shulruf, Hattie, and Dixon (2008) conclude that a six-point Likert scale is especially appropriate to research that has several variables. This above reason justified the use of the 6-points Likert scale as the study was dealing with multivariate data.

The online survey was designed using the University of Auckland’s Qualtrics Application Programme. The Qualtrics programme allows the user to apply various actions and conditions to the survey data, enabling the user to make statistical comparisons and provides a holistic picture of the responses (Hammond & Wellington, 2012) during data analysis. For example, an ‘action’ can be set up on Qualtrics with different permutations and combinations to view three conditions such as ‘How many males (gender) who did not take science (subject selection) felt that science was important to society (agreed or disagreed to a proposition).’

An online survey was preferred over paper copies for several reasons. Responses could be counted, measured and statistically analysed (Wisker, 2007) using computerised programmes like SPSS and EXCEL with the least amount of errors in data entry compared to using physical paper copies (Ritter & Sue, 2007). Online surveys have several other advantages (Ritter & Sue, 2007). In this study, it helped the researcher to reach out to the entire cohort of 300+ students in Year 13, geographically located in various classrooms during a timetabled working day within the school without having to disrupt class time or physically distribute paper copies in several of the classrooms. Students were also able to access the survey on their phones or tablets and not rely totally on computer devices in the classroom. They could also complete the survey in their own time at home or outside the class if they had access to a device since the survey was kept open for three weeks (Ritter & Sue, 2007). The researcher did not have to be physically present at the school during this period or disrupt study time. Notices and emails nearing the closing date were sent out by the principal’s nominee to allow a reminder for maximum participation.
3.5.2 Phase 2 - Semi-structured Interviews. Researcher as instrument.

The researcher was the instrument used to collect data in Phase 2. Ten consenting participants (n=10) from Phase 1 were recruited to take part in individual semi-structured interviews with the researcher in Phase 2 using a stratified random sampling technique (Tashakkori & Teddlie, 2010). The details of the semi-structured interviews are further explained.

Semi-structured interviews typically involve the participant and the interviewer, in this case the researcher and the respondent, engaging in a semi-formal conversation or interview (Hammond & Wellington, 2012). Questions are usually pre-determined but allow participants to explore issues that they feel important in the verbal interchange during the conversation (Longhurst, 2010). In his seminal work Questionnaire Design, Brace (2018) describes that semi-structured interviews for some people mean the use of open-ended questions with probing instructions. Brace (2018, p.2) holds the view that it “provides a framework for a degree of consistency between interviews conducted by a number of different interviewers, whilst providing them with scope for greater exploration than is normally possible.”

Following on from Brace (2018), in this research, sixteen questions were prepared as a guide, prior to the interview and all participants were asked the same questions (Appendix 2). When necessary some of the open-ended questions were paraphrased, with prompts provided so that participants were able to comprehend each question clearly before they answered, allowing for maximum participation by the respondents (Hammond & Wellington, 2012). The interviews were carried out in a private room assigned by the school. An ordered paper interview guide (Appendix 2) with numbered questions along with specific prompts was used for each participant. (Cohen & Crabtree, 2006).

Through the interview it was often necessary to allow flexibility and follow topical trajectories during the conversation. When participants strayed from the guide they were skilfully brought back to the topic via necessary prompts. (Cohen & Crabtree, 2006). Semi-structured interviews allowed the interviewer to collect reliable and comparable data (Cohen & Crabtree, 2006) as participants were encouraged to voice their personal opinions in a non-intimidating set up with an outsider. The questions were open-ended (Cohen & Crabtree, 2006) and the participants were prompted to be open and fearless about their opinions as answers were neither right nor wrong, which allowed participants to be explicit in their responses.

Each participant was given a specific code (A, B, C and so on) and the audio taping later recognised each student with their pseudonyms based on the codes given. This was performed to ensure the anonymity and confidentiality of the participants. This is further discussed in
detail under ethical considerations. The questions asked during the interviews were linked to the survey questions based on the responses from the quantitative data. This was planned to elicit detailed responses and provide narratives of individual opinions. A method of qualitative data analysis named Thematic Analysis (TA) Braun & Clarke (2014) was followed in this study.

3.5.3 Pre-processing stage
During the pre-processing stage the quantitative data was cleaned to improve the data quality. The following steps were involved. Firstly, participants who had not completed the entire questionnaire leaving several items unanswered had to be removed from the pool. Secondly, the data had to be reorganised to be able to mine the data in a usable format using the EXCEL programme. Thirdly a process of aggregation was followed. Aggregation is the combining of two or more attributes into a single attribute (Goldstein & Roth, 1994). In this study the 25 items in the questionnaire were listed under five specific constructs. For construct one, the five responses for each of the five attributes were aggregated into 1 single attribute. The purpose of aggregating the data is to enable data reduction. Also, aggregated data is more stable as it provides less variability. The aggregated data could then be used for exploration, explanation and visualization in data displays. During the pre-processing stage the qualitative data had to be thematically analysed (TA). The data had to be coded, re-coded and then mapped under themes. The process of TA has already been explained earlier in this chapter.

3.5.4 Sampling methods.
Since it is often difficult or nearly impossible to study all individuals in a large population, it becomes easier to sample a subset of the population. This subset needs to reflect and represent the large population as closely as possible (Acharya, Prakash, Saxena & Nigam, 2013). There are two approaches to sampling. Probability or random sampling is a sampling technique in which all the subjects of the population or everyone gets an equal chance to be selected as a part of the representative sample (Field, Pruchno, Bewley, Lemay Jr & Levinsky, 2006). This type of sampling usually follows an objective method and results are often considered to be unbiased from statistical inferences. Non-probability sampling or non-random sampling is a method of sampling wherein it is not known which individual from the population will get selected as a part of the sample. There is no guarantee that each individual has a definite chance of being included in the representative sample (Field, Pruchno, Bewley, Lemay Jr & Levinsky, 2006). It follows a subjective method and may produce biased results from analytical inferences. A probability sampling technique was followed in this study. A sampling frame using specific sampling parameters (Turner, 2003; Punch, 2013) was set up.
A sample frame is a set of source materials from which the sample is selected (Turner, 2003). These included the emails of the consenting participants, ethnicity, gender, choice of science and non-science subjects. A stratified sampling technique (Tashakkori & Teddlie, 2010) was then used to recruit 10 members.

While the quantitative method recruited a large sample size (N=104) of consenting participants from the total population of 300+, the qualitative method used a small sample (n=10) of participants. The large sample was recruited through the principal and form teachers at the school using a web link. Since a sample group of 10 participants was required for phase 2 of the interviews, a stratified random sampling technique of separating the population elements/individuals into groups (Tashakkori & Teddlie, 2010) was carried out. All participants who had consented to take part in phase 2 were separated into seven groups or strata based on the ethnic information and science/non-science options given on the questionnaire. These strata included European, Samoan, Māori, Fijian Indian, Indian, Asian and Other. The strata sizes varied for each group as some were bigger than others. Once the stratification was completed for each group a simple random sampling was applied to choose the ten participants from the seven strata. This was done generating random numbers for each stratum and picking the ones that came up on the calculator. A total of ten participants, including three male and seven female students were recruited for the interviews.

On the given day, several participants who had consented to participate were away on a school trip and new adjustments were made to include participants to best represent the stratified sampling process. With the constraints of senior students having outside representatives and university providers giving them information in the library a few participants could not be reached. The outcome therefore was carried out to the best of the researcher’s ability. This also explains why there were fewer males than females at the interviews as indicated by the transcript analysis.

3.6 The School Selection

From the literature it is understood that both participation in science and enrolment into secondary science has declined in New Zealand (Hipkins & Bolstad, 2005, Hipkins, Roberts, Bolstad & Ferral, 2006), and in other counties like Australia and the UK (Lauder, 2011; Kennedy, Lyons & Quinn 2014; Wilson and Mack 2014). This raises a concern for all educators and for the future of New Zealand as the country gears towards fulfilling the needs for a “STEM-competent workforce for a more innovation-focused society economy” (Ministry
of Business, Innovation and Employment New Zealand, 2014, p.15 for Ministry of Education). Declining enrolment numbers in science (Hipkins & Bolstad, 2005) are also more pronounced among Māori and Pasifika students in New Zealand leading to further inequity (Marriott & Sim, 2014). The 2012 PISA report states that Māori and Pasifika student performances were significantly below the OECD average. “Achieving equity in educational attainment for Māori and Pasifika tertiary students is stated as a key objective in nearly all of the universities’ mission statements or charters, and equity committees have been set up to ensure equitable outcomes.” (Nakhid, 2011, p.532). A lower proportion of Māori and Pasifika students achieved at the highest levels of proficiency in science, and these students were over-represented at the lower levels when compared to the New Zealand average. The low achievement might well be a factor influencing students option choices in Year 13. South Auckland schools tend to show high enrolments of both Māori and Pasifika students. Schools in South Auckland were of interest to the researcher as student voices could be evaluated if such a school agreed to take part in the study.

To understand the underlying problems the researcher wished to recruit students from a school with the following parameters.

- A Year 9 -13 secondary school with a roll of over 1500.
- A Decile rating of 1 – 3.
- Schools located in South Auckland.
- State school.
- Not include the school where the researcher was currently employed.

3.7 The school setting

To approach schools that aligned with the above parameters the researcher perused through the Education Review Office (ERO) Reports available online. The Education Review Office (ERO) is the New Zealand government department that evaluates and reports on the education and care of students in schools. A few schools were listed by the researcher. The school initially approached was decided based on the ERO report, the school’s standing within the community as well as reviews from local newspapers and other media. The selected school had the following characteristics: a robust innovative leadership from its senior leadership team; a very strong digital and collaborative learning focus; extensive community engagement with external expertise and local business leaders and a large science department with several staff members. It was also a large sized co-educational school with over 2000 students.
enrolled in years 9 – 13. Māori and Pasifika enrolment contributed to approximately 25% and 45% of the total school population. The school was culturally diverse in terms of both teachers and students. The bi-cultural vision of the school was supported by a strong whānau system.

The school followed the National Certificate of Educational Achievement (NCEA) curriculum and students gained the official NCEA qualification at Levels 1, 2 and 3 via Standard Based Achievement credits leading to tertiary education pathways. Science is a compulsory subject from years 9 to 11 at this school. The researcher approached the Board of Trustees through the principal to gain permission and entry to carry out the research study with an assurance that the school and participants would receive a summary of the results. The selection of students and permission for the study is described in the next section.

3.8 The selection of students

The researcher phoned the school to get an initial appointment with the principal. During the first meeting, the principal was provided with details of the research study including the School Participation Information Sheet (PIS -School. Appendix 5) and the School Consent Form (CF-School. Appendix 6). It was explained that the researcher wished to approach all students in the Year 13 cohort to take part in the study during Phase 1. The participants who consented to this would need to answer a ten minutes online questionnaire. Those willing to participate in Phase 2 would be recruited for the audio-recorded semi-structured interviews from those who consented on the online form in Phase 1. Once permission was granted the researcher met and explained the two phases of the study to the Year 13 form teachers who were involved in assisting the researcher with the study.

3.8.1 Phase 1

After the principal had officially agreed to the researcher’s access to the school, the researcher met the form teachers of the Year 13 classes during a morning briefing. After introductions, the principal explained the purpose of the researcher’s study followed by the researcher’s request and explanations of how the study would be carried out during Phase 1 followed by the selection of students for Phase 2. Since the researcher was keen to gather as much quantitative data as possible, all students in the Year 13 cohort (approximately 300+) were requested via the form teachers to take part in phase 1 of the study.

The form teachers were sent a detailed email from the school principal about the research study and the specific requirements of them during the form class to avoid wasting any learning time during regular teaching periods. The email included a web-link created by the researcher to an online questionnaire for all participants. The form teachers uploaded the web-
link on the school learning management system for each of their form classes. The questionnaire was then administered during form time by each of the form teachers requesting all year 13 students who had read the Participation Information Sheet (see Appendix 3) and Consent Form (see Appendix 4) to complete the same if they wished to participate. The online questionnaire was completed using a device such as a phone, tablet and computer. The participants needed approximately 10 minutes to read the online forms and complete the questionnaire. The form teachers/Kaitiaki were also provided with paper copies of the PIS, CF and questionnaires for students who had no access to such devices. All Year 13 students were also emailed the details and web link by the deputy principal of the school requesting participation in this research study. This further enabled students who were absent from school or busy at form time to complete the questionnaire at a time that best suited them.

Students who wished to participate only in Phase 1 remained completely anonymous in this study. Those who participated in Phase 2 had their identities kept confidential as they had provided a contact email address for recruitment to Phase 2. Ten students were recruited from the pool of consenting students and interviewed by the researcher. A random stratified sampling technique was used to recruit 10 of these participants.

3.8.2 Phase 2
A total of ten participants were interviewed during a day assigned by the school. The researcher sent the names to the principal who organised the office staff to create a schedule that suited the students. Each audio-recorded interview lasted between 8 to 15 minutes. All interviews followed the order of the 16 questions in the interview guide (Brace, 2018) The interviews were audio recorded using a Dictaphone rather than note-taking. This process allowed constant eye contact and sociable body language of the interviewer with the participants, putting them at ease (Rugg 2006). The audio recordings were transcribed by the University of Auckland’s authorised transcriber for coding and thematic analysis at a later period. A detailed thematic analysis was then carried out.

“Thematic analysis (TA) is a method for systematically identifying, organizing, and offering insight into patterns of meaning (themes) across a data set. Through focusing on meaning across a data set, TA allows the researcher to see and make sense of collective or shared meanings and experiences” (Braun, Clarke & Terry, 2014, p. 57). In this study a six-phase approach detailed in several studies by Braun, Clarke and Terry, (2014), Clarke and Braun,
(2013), Braun and Clarke (2006) was followed. The six phases of this analysis based on Braun & Clarke’s model (2014) used in this study is described below.

Phase 1: Familiarization with the data
The first step during this phase included the transcription of the data from audio recordings to typed scripts. Each participant’s interview was transcribed by an official University of Auckland designated transcriber. The total of ten, typed interview transcripts from the 10 respondents formed the initial data set (Braun & Clarke, 2006). The data was then re-read by the researcher along with audio narratives to ensure that the transcription was accurate and verbatim. Several notes of initial ideas from all data items from the entire data set was made by “reading data as data” (Braun & Clark, 2014). In this procedure words were actively, analytically and critically analysed by the researcher while observing potential latent and semantic themes in the data set. These were noted during the initial reading process. Data items (Braun & Clarke, 2006) namely, individual pieces of data that formed a part of the data set were analysed and organised. These were grouped under similar headings. Individually coded chunks of identified data within a data item referred to as data extract (Braun & Clarke, 2006, p. 79) were then used for TA.

Phase 2: Generating initial codes
According to Saldaña, (2009; 2015, p.3), “a code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data.” Codes identify a feature of the data. Attride-Stirling, (2001) explains that coding is the process of reducing data and organising it into meaningful and manageable text segments. In order to produce initial codes that were interesting, meaningful and showed a pattern, the researcher read and re-read the transcripts several times before coding each transcript manually underlining common ideas, using highlighter pens to enhance similar ideas, using post it notes and writing short notes on the transcripts where patterns emerged. Being thorough, inclusive and comprehensive during this process by including all items of the data set was very useful (Braun & Clarke, 2006). The researcher initially had over 15 open codes (Kendall, 1999). These included similar chunks of data from all data items. On re-reading the data items under the open codes, several overlapping codes were eliminated. This was followed by setting up 10 axial codes where related codes with linked ideas were compiled together by inductive and deductive thinking (Kendall, 1999). The researcher was finally able to focus on these 10 specific codes. A sample annotated, and coded transcript is provided (Appendix 7). Exemplars of data extracts for the
10 codes/labels developed during the coding process are presented in the appendix (see Appendix 8 & 9)

**Phase 3: Searching for themes**

“A theme captures something important about the data in relation to the research question and represents some level of patterned response or meaning within the data set.” (Braun & Clarke, 2006). This step uses the competency of pattern recognition (Boyatzis, 1998). The theme helps to organise similar observations and interprets similar or dissimilar phenomena (Boyatzis, 1998). In this study for example several factors including (i) parents and family members (ii) peer influence (iii) the NCEA credits (iv) entry into tertiary institutions (v) career prospects (vi) financial gains were a combination of several external factors that emerged as a distinct theme in influencing student’s decision making. Colour coding and note making was helpful at this stage to bring together various data extracts under this theme of “external factors.”. The theme-piles were organised using the EXCEL programme (see Appendix 10). This allowed the extracts to be moved around easily during this elaborate process of organising them into specific themes. It followed a similar *cut and sort method* offered by Ryan and Bernard, (2003, p.88), who postulate that “themes emerge from both data (an inductive approach) and from the researcher’s prior theoretical understanding (an a priori approach) of the phenomenon under study.” Drawing a mind map using the programme ClickCharts relating to all possible themes helped in initial classification at this stage. Both positive and negative elements from the entire data set was include at this stage (Boyatzis, 1998).

**Phase 4: Reviewing themes**

Sub-themes were identified, and the significance of individual themes were viewed in response to the initial research questions. Analytical memos were written as notes on transcripts and post-its. “Analytic memos are somewhat comparable to researcher journal entries or blogs – a place to “dump your brain” about the participants, phenomenon, or process under investigation by thinking and thus writing and thus thinking even more about them.” (Saldaña, 2015, p.42). This allowed not only the re-shuffling of the data extracts but helped the researcher to understand the emerging phenomena. The individual data set for each candidate was completely analysed and data extracts were pooled into common themes if themes overlapped. Each coded extract within a theme was double checked to see that there existed some significant semblance of a match to the theme. Themes were further combined or broken down based on data extracts. Once this was completed a final thematic map with four significant themes was generated. This is depicted and discussed in the next chapter titled Findings.
Phase 5: Defining and naming themes
It is important to provide clear definitions of what the theme concerns. This includes characteristics and issues both positive and negative related to the theme (Boyatzis, 1998). It also involves the refinement of sub-themes and providing an analysis to the complete data set.

Phase 6: Producing the report
Analysing the complete data set and writing the narrative was an iterative process. It required both inductive and deductive reasoning by the researcher. It was essential to interpret personal experiences provided by the participants in to a logical sequence of meaningful interpretation without any bias. The respondents’ narratives related in their words in conjunction with the research questions were used to complete the analysis.

3.9 Ethical considerations
Prior to the collection of data, ethical approval was granted by the University of Auckland Human Participants Ethics Committee on (24/05/2018) for 3 years using a reference number of (021143). This was listed on all forms presented to the school and the participants prior to gaining access to the school and during the study at the school. The requirements of the school and participants were clearly articulated to the school’s Board of Trustees and principal via the students’ PIS and CF (see Appendix 3, Appendix 4) schools’ PIS and CF (see Appendix 5, Appendix 6). It was clearly stated that all records and any paper copies from either Phase 1 or 2 would be securely stored for three years with the supervisors at the University of Auckland. Ethical dimensions are paramount in social science research especially when the researcher is dealing directly with the participants. Stake (1998) in Bridges, (2016, p.354) states that “Researchers are guests in the private spaces of the world. Their manners should be good and their code of ethics strict.” Following on from this decree, the researcher made all efforts to ensure that the process was carried out ethically. The steps that were undertaken included obtaining consent as well as maintaining anonymity and confidentiality where possible.

3.9.1 Informed consent
The participants’ decision to participate in both Phase 1 and Phase 2 were entirely dependent on their personal consent. They were all provided with PIS and CF that enabled the students to know about the research and refuse to take part in it if they didn’t want to (Chapman, McNeill & Mcneill, 2005). Year 13 students are mostly 17/18 years of age and were therefore able to give informed consent as adults towards this study.
3.9.2 Anonymity and confidentiality
In social research settings all participants have rights and the researcher has the responsibilities and obligations to ensure that these rights are maintained (Chapman, McNeill & Mcneill, 2005). In keeping with the above norms of social research the participating school was identified only as School A all through the study. During Phase 1 most participants answered an anonymous questionnaire on the web. Only those students who wished to take part in Phase 2 provided an email contact. While these students were no longer anonymous, confidentiality was maintained during Phase 2, as interviews were conducted in a private room at the school and pseudonyms were assigned to the students during all the reporting from narratives of the Phase 2 study. Pseudonyms have been used in all subsequent discussions to prevent any form of identification of the participants (Grinyer, 2002). The interviews were audio-recorded and transcribed by a university-approved transcriber who signed a confidentiality agreement. Given that the research did not deal with any sensitive issues there were no fears of any accidental disclosures of information at any given time (Wiles, Crow, Heath & Charles, 2008).

3.9.3 Participant’s right to withdraw
The participants had the right to withdraw from taking part in the questionnaire or interview at any stage without having to give any reasons. Since the interview was audio-recorded. The participants had the choice to have the audio-tape turned off at any time during the individual interview if they felt compromised or uncomfortable in answering any questions (Merriam, 1998). This allowed the participants freedom of choice.

3.9.4 Conflict of interest
Any conflict of interest or power imbalance issues were minimised as the researcher was not a teacher at the school. The researcher did not know any of the students personally at this school and had a neutral positionality of an outsider. Interviews with students were non-judgemental and independent (Bonner & Tolhurst, 2002). As an outsider, it was easier to build a rapport with the participants as well as increase the opportunities for in-depth discussions as there were no personal conflicts of interest between the participant and the interviewer (Alder & Alder, 1994 in Bonner & Tolhurst, 2002).

3.10 Pilot study
A pilot study can mean either a feasibility study or the pre-testing of an instrument such as a questionnaire or interview schedule (Teijlingen & Hundley & Graham, 2001). A pilot study is an important component of research design as it helps the researcher to gauge how accurate the instrument used in the research may prove to be for the actual study. In this instance, the
time used to answer the questionnaire, the appropriateness of the questions used either in a survey or interviews, use of suitable or complicated language are all crucial information to obtain reliable and accurate results (Teijlingen, Hundley & Graham, 2001). Teijlingen, Hundley and Graham (2001) emphasize that in medical research pilot studies help to identify possible practical issues that may arise during the research procedure.

To minimise all errors that could arise during the use of the methods for final data collection, the researcher ran the questionnaire past several colleagues within the science department at her own school to ensure that the statements were meaningful within each construct and worded correctly in terms of the language used. Some suggestions made by proof readers were carefully noted and corrected prior to the pilot run. The online questionnaire was then run with a group of Year 13 students at the researcher’s school with prior permission from the principal and teachers of the students. A group of five students from science and non-science subjects were also interviewed using the interview questionnaire. Feedback from the students enabled the researcher to recognise that there were some glitches within the questions, and these had to be rectified. Some of these glitches included the following:

- The number of questions had to be reduced from 30 to 25 to avoid respondent fatigue (Brace, 2018) as participants’ feedback included the request to reduce the number of items.
- A new filter had to be set up to allow students to quit the programme if they did not consent to answering the questionnaire.
- The initial online questionnaire lacked uniformity regarding the data collection for demographics. The initial online asked students open ended questions and the data collected was unmanageable. This was rectified by adding specific filters (Brace, 2018).
- A similar problem arose over the various subject choice data collection as the initial online form asked students to fill in the various subjects yielding huge data. This was minimised by allowing students to tick boxes for the subjects that they had chosen.
- A set of questions repeated themselves automatically and resulted in a double data set for a construct. This was rectified for the final online survey.
- A few questions for the semi-structured interview had to be re-written in a simpler language as the pilot students found the language difficult to comprehend (Brace, 2018).
- Two questions seeking similar answers appeared in two sections and were pointed out as being repetitive. This had to be changed.
- One of the questions appeared to be a double-barrelled question, and the coordinating conjunction “and” had to be removed along with a second idea to avoid a compound sentence.
- Another question that appeared to seem like a leading question had to be modified and the sentence had to be restructured.
The pilot study student interview recordings were done using a cell phone. Recordings were disrupted by incoming calls and text messages and a few recordings were incoherent. The cell phone was replaced with a Dictaphone for the final interviews to avoid these issues (Brace, 2018).

The pilot study proved to be very insightful leading to the researcher making several changes before it was set up to be administered in the school selected. It also helped to establish the sampling frame, the success of proposed recruitment approaches, identifying logistical problems, designing the research protocol and identifying that it was workable (Teijlingen, Hundley & Graham, 2001; Brace, 2018). While advancements in technology, including web exemplars allow for surveys to be designed easily, a pilot study where feedback is scrutinised and taken on board plays a major role in overcoming survey design pitfalls.

3.11 Data Analysis

Tashakkori and Teddlie (2003, p. 352) define the fundamental principle of mixed methods data analysis as “the use of quantitative and qualitative analytical techniques, either concurrently or sequentially, at some stage beginning with the data collection process, from which interpretations are made in either a parallel, an integrated, or an iterative manner.” In the researcher’s case an integrated approach was used.

To initiate data analysis the researcher had to ensure that all data collected during this study was clearly set aside and labelled under the two main data sets namely (1) Quantitative data and (2) Qualitative data. The Quantitative data including all the demographic information of participants and responses from the 25 items questionnaire using the Likert were exported as csv files from the Qualtrics data application programme into EXCEL. All qualitative data from the 10 recorded interviews were initially filed as voice recordings before they were transcribed by the University of Auckland’s official transcriber into word files. These files were manually coded and used for further data analysis. They were both laborious and iterative processes that included examining each set of data several times to avoid mistakes.

3.11.1 Rationale for data analysis process

Tashakkori and Teddlie, 2003 postulate two important rationales namely, representation and legitimation for conducting the mixed method data analyses. The rationale of representation allows the researcher to use the data from the two approaches to attain the following (Greene, Caracelli & Graham, 1989 in Tashakkori and Teddlie, 2003) : (i) triangulate results (from the two sets of data) (ii) complement results (clarify or elaborate results from one approach with the other) (iii) develop results ( use results from one approach to enhance or further the other approach (iv) initiate new research questions from contradictions or paradoxes from the two
data sets (v) expand on the initial inquiry. The rationale of *legitimation* (Tashakkori and Teddlie, 2003) allows researchers to validate their findings based on trustworthiness, dependability, confirmability and transferability using analyses from both data types. The use of categories, themes and typologies are restricted not only to qualitative data but can be identified in quantitative analysis as well and statistical data can also be generated from qualitative categories and themes (Witcher, Onwueghbuzie & Minor, 2001, cited in Tashakkori and Teddlie, 2003). The researcher used the rationale for *legitimation* in this study as she was trying to validate the findings against the literature as well as the student voices from the study. Table 2, on the following page, shows a summary of the various stages carried out towards the data analysis during this study.

*Table 2 Stages of Mixed Methods Data Analyses Process*

<table>
<thead>
<tr>
<th>Stages of Mixed Methods Data Analyses Process</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Data reduction</strong></td>
</tr>
<tr>
<td><strong>2. Data Display</strong></td>
</tr>
<tr>
<td><strong>3. Data transformation</strong></td>
</tr>
<tr>
<td><strong>4. Data correlation</strong></td>
</tr>
<tr>
<td><strong>5. Data consolidation</strong></td>
</tr>
<tr>
<td><strong>6. Data comparison</strong></td>
</tr>
<tr>
<td><strong>7. Data integration</strong></td>
</tr>
</tbody>
</table>

Adapted from (Tashakkori and Teddlie, 2003).
3.12 Trustworthiness

In all forms of research, the reliability and validity of the methods form the important foundations to the trustworthiness of the research study. According to Joppe (2000 reliability and validity is

“The extent to which results are consistent over time and an accurate representation of the total population under study is referred to as reliability and if the results of a study can be reproduced under a similar methodology, then the research instrument is considered to be reliable.” “Validity determines whether the research truly measures that which it was intended to measure or how truthful the research results are. In other words, does the research instrument allow you to hit "the bull’s eye" of your research object?

Quoted in Golafshani, 2003, p.598-599)

In this study the researcher provided detailed information about all the methods and instruments used during the study. This allows for transferability (Shenton, 2004) of the methodology for another person to follow the same procedure. It is important to understand that this study was carried out in a single school and while the method is repeatable and dependable along with the results being truthful to this situation it may not always be possible to have the same outcome for another group of participants at another school where internal or external factors may vary widely influencing the results (Shenton, 2004).

The validity to the research is shared through the cohesion of methods, approaches and techniques leading to the findings. To ensure this validity the researcher has shared all the results from both the quantitative and qualitative data and compared the findings against the research questions in the next few chapters including generalisations and significance.

3.13 Summary

This chapter has outlined the methodology and methods in detail. The justification of a pragmatic paradigm was explained in context to social science research and the use of a mixed methods approach. A visual representation of the steps to the mixed methods approach was also included. The researcher has detailed the processes of how sampling was carried out and outlined the steps to the data analysis. To ensure fairness to all participants the researcher has stated how ethical considerations were followed and the trustworthiness of the study maintained. The next chapter details the findings and discussions from the quantitative and qualitative methods.
Chapter Four: Findings

4.1 Introduction
The principal outcomes from the data collected during Phase 1 and Phase 2 of the research are described in this chapter. Phase 1 of this study focussed on gathering the quantitative data from a 25 items survey. The findings from this survey are outlined under the heading Quantitative Data under section 4.2. This is followed by the data findings from the semi-structured interviews conducted in Phase 2. The data are described under the heading Qualitative Data in section 4.3. It is then followed by the summarisation of how both types of data complement each other and conflict in some ways. Section 4.4. provides a summary to these findings.

4.2 Quantitative Data
To understand the statistical findings and discussions it is best to review the survey administered to the participants. The survey as described earlier (see Appendix 1) consisted of 25 items under five main constructs. The various statements in the survey had no natural ordering (Agresti and Kateri, 2011). The nominal data in this study were collected using a 6-points Likert scale. Participants were asked to pick one out of the given 6 alternatives, resulting in a single-select response option. The responses from the Likert scale to the five statements under each category was summed up to produce an average value. The nominal data (Agresti and Kateri, 2011) was then analysed by calculating the share of responses in each category. The researcher then summarised the proportion of the population that chose each category in percentages using the Excel programme.

140 participants from the Year 13 cohort of 300+ students at the school taking both science and non-science subjects attempted the questionnaire. However, only 102 entries were able to be counted as 38 participants left the online survey incomplete in several areas.

The following shows the distribution of participants by ethnicity taking one or more science subjects (in red) and participants not taking science subjects (in blue)
Participating students (N=102) included a total of 13 Māori students (n=13), 51 Pasifika students (n=51), 4 Indian students (n=4), 11 Asian students (n=11), 12 NZ European students (n=12) and 11 from other ethnicities (n=11) as indicated along the X axis of the graph. For convenience all responses have been recorded as a percentage count (indicated along the Y axis).

The group listed “other” was made up of Middle Eastern and other minority groups. The graphs depicted in the next few pages show summarised responses of both science and non-science students to various statements from the survey. Rounding off to the nearest whole numbers needs to be taken into consideration for some of the results.

**Figure 1 Percentage of participants from Year 13 students taking science or not taking science based on ethnicity**
Figure 2 Response to individual interest in science in Years 9 & 10

Figure 2 represents the summarised results of participants’ personal attitudes and feelings to five specific statements listed under the main construct Individual interest in science. The statements were designed to understand if students found science topics easy to understand, if there existed a fun element involved in viewing science content and if the learning at school and the application of science had relevance to their everyday life. It was important to analyse if these attitudes were intrinsic motivating factors in Years 9 and 10 that stimulated students to pursue science subjects in Year 13.

The results indicated that both science and non-science students had an overall positive individual interest in science to varying degrees as evident in the first three bars of the graph. It was found that around 85% of the respondents (91% Science and 78% non-science) agreed that Year 9 and Year 10 science held their interest and only 15% of respondents (9% of science and 22% of non-science) had somewhat negative attitudes to individual interests in science based on their levels of disagreement to the various statements.

The above results clearly indicate that a considerable sample of the Year 13 cohort who had enjoyed science for two years during their junior science classes had not continued with secondary science subjects in Year 13 (non-science, n=65).
Figure 3 Response to the ease of understanding science in Years 9 and 10

Figure 3 shows the responses to the specific statement; *it was easy to understand science topics in Years 9 and 10* within the main construct of *Individual interest in science*. An overwhelming positive response was evident from both science (100%) and non-science students (85%). Findings clearly indicated that for a large segment of the population the science topics were easy to comprehend in junior science classes. 16% of non-science students indicated a disagreement to this statement versus a 0% response from science respondents.
Figure 4 Response to the application of science to everyday life

Figure 4 depicts the responses to the specific statement *the science that I learnt at school can be applied to everyday life* within the main construct *Individual interest in science*. This statement elicited a 69% positive response from non-science students to varying levels of agreement compared to 89% from science respondents. A greater percentage (31%) of non-science students disagreed with this statement.
Figure 5 Response to external factors in decision making

Figure 5 represents the summarised results of participants’ responses to five specific statements listed under the main construct Influence of external factors. External factors explored in this study included the influence of peers, family members, school counsellors and study choices at university as decision making external determinants. The graph on external influences showed varied responses between the science and the non-science students. While the science students were more inclined to be positively influenced by external influences (21% strongly agree, 23% agree) the non-science students were less likely to have been influenced by external factors as indicated by the results (13% strongly agree, 21% agree). A similar trend emerged with the strongly disagree choice on the scale for this construct as indicated by the disagreement percentage (18% science vs 14% non-science). This indicates that while external influences are perceived to have had a strong influence in the decision making for many of the students in their subject selection it has not played a significant role in influencing decision making among many others, and both science and non-science students show similar trends on this item. However, this is further analysed in conjunction with interview responses to the extent of how extrinsic factors play a role in decision making.
Figure 6 Response to peer influence on subject choice

Figure 6 depicts the responses to the specific statement *My peers have influenced my subject choice* within the main construct *Influence of external factors*. This statement was intended to explore if peers had any noteworthy influence on participants’ decision-making processes as an external factor. As shown above it illuminated various responses by science and non-science participants. An overall 51% of science participants and 55% non-science participants indicated that they were influenced by their peers. The answers to this statement elicited an almost equal response from both groups as shown above.
Figure 7 Response to parent and family influence on subject choice

Figure 7 focused on the responses to the specific statement *My parents and family have influenced me on subject choice* within the main construct *Influence of external factors*. Responses by participants to the above statement indicated almost unanimous responses to overall agreement namely 60% from non-science participants and 59% from science participants. Family members seemed to have an influence on subject selection in some way for a large percentage of the population. Overall disagreement responses in both science and non-science groups were almost similar. An equal proportion of non-science and science participants seemed not to have been influenced by family members in choosing their subjects.
Figure 8 Response to science self-concept

Figure 8 represents the summarised results of participants’ responses to five specific statements listed under the main construct I believe that I have positive science self-concept. The statements in this construct were designed to gauge the participant’s answers related to self-concept attributes such as abilities in science, achievements in science, understanding of science concepts and assessment grades obtained during the years of experience with science. The purpose was to uncover any existing relationship between these attributes and motivation to taking science.

From the above graph it is apparent that there exists a strong correlation between positive science self-concept and choosing science subjects in year 13. This graph provides definite indication that science self-concept influences students’ science options if they have a strong academic self-concept. The emerging results from this specific statement links to the research question whether science self-concept is indeed an intrinsic factor that plays a role in subject selection for science students and likewise if academic self-concept in particular subjects drive students to opt for specific subjects.
Figure 9 Response to the ease of understanding science concepts

Figure 9 focuses on the responses to the specific statement *Science concepts are easy to understand* within the main construct *I believe that I have science self-concept*. Results show an emerging pattern where students taking science are those who understand science concepts more easily. This is supported by the 75% of science respondents showing varying degrees of agreement to this statement as compared to 64% of the non-science students. There seemed to be a considerable percentage of both science and non-science students for whom science concepts were not easy to understand. These responses revert to the research question why students may take science even though they find science concepts difficult to understand but still cope with the subject at senior levels.
Figure 10 Response to the attainment of grades

Figure 10 focused on the responses to the specific statement *I have attained good grades in science* within the main construct *I believe that I have science self-concept*. The results above are of an interesting nature. From this graph it is observed that the results from both science and non-science participants indicate that their grades were good when they were involved with science. The question then arises, if the non-science students attained good grades in science why did they not persevere with science subjects in Year 13? Non-science students who understood science topics and attained good grades in previous science classes still refrained from taking science subjects in their final year. It leads us to the question whether extrinsic factors have much to do in decision making.
Figure 11 Response to engagement in science classes

Figure 11 summarises the results of participants’ responses to five specific statements listed under the main construct *I was engaged in Year 9 & 10 science*. Statements that linked opportunities and experiences provided by the teacher such as collaboration, science experiments, use of internet, games & videos to understand science lessons, competitions in science, interaction and engagement in group activities as well as the relevance of science to real life were included. This construct explored the research question to understand if situational influences in the classroom and pedagogical methods employed by the teacher were external and extrinsic factors that influenced decision-making. The results very clearly indicate that for the majority of participant, both science (84%) and non-science (76%) engagement in the science classes were high during junior science years. Yet the question arises as to why students who were engaged in junior science did not pursue with science in their final years.
Figure 12 Response to attentiveness in class with life examples

Figure 12 depicts the responses to the specific statement I am more attentive in class when my teacher illustrates science concept examples from daily life within the main construct, I was engaged in Year 9 & 10 science. There was strong agreement for this statement by both science and non-science students. The disagreement responses from the non-science students was 20% and a low 3% from science participants.
Figure 13 Response to group discussions making lesson interesting

Figure 13 illustrates the responses to the specific statement *Group discussions make science classes more interesting* within the main construct, *I was engaged in Year 9 &10 science*. An overwhelming majority of 81% of science and 78% of non-science respondents agreed to various degrees that group discussions made their science lessons more interesting. As learning styles are often very different for various individuals, the similar disagreement levels for science and non-science participants could be well be postulated from understanding that some individuals prefer to work by themselves rather than in groups.
Figure 14 Response to the importance of science for career and employment prospects

Figure 14 represents the summarised results of participants’ personal attitudes to five specific statements listed under the main construct Science is important for career and employment. Statements used in this construct related directly to decisions of subject selection based on career prospects in the future including science related careers, salaries in science jobs and following tertiary science study as a stepping stone to future jobs. 85% of science participants agreed with these statements and their selecting science is obviously understandable. These results may be an indication that students at Year 13 are probably taking subjects that will lead on to further studies or jobs in the future. These responses tend to show calculated thoughts among adolescents. However, it is not possible to rule out the fact that science may have been an option for non-science participants (67%) who felt that science was important for careers from results above and yet had not taken science.
Figure 15 Response to understanding science in relation to career benefits

Figure 15 illustrates the responses to the specific statement *Understanding science will benefit me in my career* within the main construct, *Science is important for career and employment.* The findings reveal that science respondents clearly agreed to this statement. Though non-science students did not strongly agree with it, they did show some agreement.
Figure 16 Response to subjects selected in relation to university study

Figure 16 illustrates the responses to the specific statement *I selected subjects based on what I will study at University* within the main construct, *Science is important for career and employment*. The responses on subject selection related to tertiary study was prominent among the science participants (89%) over non-science (66%) participants. Given the possibility that many students were probably not going into university or had other pathway plans the disagreement levels for this item response could be extrapolated.

**Summary of the survey results**

From the results above it can be clearly seen that the increasing number of variables result in differentiated responses from individuals for different constructs. It is evident that for most participants irrespective of them taking science (n=37) or not taking science (n=65) in Year 13, science concepts, the science classroom experiences as well as understanding the science topics were enjoyable in the junior years. Some of the responses between the two groups are even too close to allow for a distinct demarcation. Thus far, 65 participants in this study have clearly not continued with science regardless of ease of learning and being interested in the subject in earlier years. The reasons for these decisions are understood in concurrence with the qualitative data analysed together with evidence from the supporting literature in the next chapter.
4.3 Qualitative Data

To understand the findings from the semi-structured interviews gathered from the qualitative data it is essential to look at the questions posed by the interviewer to the participants (Appendix 2).

The information provided by the participants was examined using a coding system. The entire data from the complete set of transcripts (n=10) of participant’s narratives were compressed into smaller analysable units based on several categories (Merriman, 1998) under various codes. These 10 participants included 5 science and 5 non-science Year 13 students who had earlier done the survey and had consented to the interviews. A sample coded transcript is provided in the appendix (See Appendix 7) to understand how the coding was carried out.

What emerged from the filtering and condensing of the coding process were 10 specific coded and summarised data extracts (See Appendix 7). Analysing these data items in detail allowed the researcher to piece together various aspects of the jigsaw puzzle of this decision-making process. An insight into how the participants’ thought processes worked regarding their final subject choices in Year 13 emerged. A holistic picture of these findings is described under four specific themes.

A summarised thematic map on the following page illustrates the basis on which the four specific themes were founded. These four themes then formed the groundwork of comprehending participants’ thought processes in decision making. Each theme is discussed with examples from the participant’s views and narratives in the next section. It is to be noted that these perceptions and understandings are based on several variable factors that directly and/or indirectly, to a lesser and/or greater extent influenced and impacted subject choice decisions of the 10 interviewees. Hence, there are several overlapping narratives from each of the participants for the different themes. Emerging evidence points to the central fact that decision making in all participants is influenced by multiple factors. However, some factors play a more significant role than others for each one, depending on their personalities, individual desires for the future and family influences.
Figure 17 Thematic Map showing the 4 main themes in final analysis.

(Adapted from Braun and Wilkinson, 2003)
4.4 Themes derived from the qualitative data

Theme 1. Experiences in Years 9, 10 and 11 Science as a factor in decision-making.

This theme emerged as a result of several probing questions presented to the participants in relation to the research questions. It aimed at understanding whether their experiences in the earlier years of compulsory science was a factor that had encouraged participants to take secondary science. The theme mapped participants’ involvements and experiences from previous science classes. The theme also summarised both positive and negative experiences narrated by the participants from the personal experiences they recalled from Years 9, 10 and 11.

Most participants, irrespective of whether they were pursuing science or not, clearly stated that their experiences in junior science (years 9 & 10) classes were memorable. When asked about primary and intermediate school experiences, their memories were sketchy, but they clearly remembered experiences in the junior science classes. The majority of the participants (nine out of ten) related that they enjoyed their science lessons in Years 9 and 10 as their teachers had provided hands-on activities. These activities were described as science-fair experiences, participation in experiments, field trips, collaborative group activities, groups discussions, making models and watching interesting videos.

Apelu, a current Year 13 science student taking chemistry and physics, justified his passion for physics including mechanics, all through Years 11, 12 and 13 from his very early science experience of a trip to Extreme Edge in Auckland in Year 10 where the students were involved in rock climbing during the activity. Apparently, this experience created a buzz for him and triggered his interest in science, specifically physics. He was able to associate this experience in junior classes to his current physics passion in Year 13 of gears, anchors, pulleys forces, friction, fall factor, GPE (gravitational potential energy), types of climbing (alpine climbing, bouldering, top rope, traditional or trad climbing), trad gear like cams and nuts, gears and anchors and more. A one-off class trip had motivated a year 10 science student into continuing with physics. This activity also had a personal bearing on his life when he went out fishing with his uncle and was able to relate to the physics of fishing including the effect of casting the fishing line, torque, friction, pulleys and various forces taught in the classroom. Classroom pedagogy had generated an indirect influence in his personal life. Strangely, Apelu had never been interested in science in primary or intermediate school as he could not recall anything exciting or positive from then.
Iosefina, another science student, could remember in detail specific practical activities like the “experiment with dry ice” and enjoyable field trips. She had thoroughly enjoyed science in junior years because of the engagement and fun activities. Yet, she provided some disconfirming evidence that she couldn’t remember where the field trip took place, even though she had enjoyed it.

Some of these perceptions are better understood in the participants’ own voices. Excerpts from student voices are narrated below to gain an insight into how junior science influenced these students.

Fredrick, a student who had not taken science subjects but was pursuing technology and hard materials including woodworks was clear about following a career pathway in carpentry. He, like most others enjoyed practical science over written work but was certain that science was not his future as he preferred to follow a career pathway in the building industry as a carpenter. Recalling his science experiences, Fredrick talked about a memorable activity.

“It was like beer and stuff, I liked all the practical work that we did it was pretty fun that is about it. Yeah, we did a few group activities and stuff. I did not like writing” (Fredrick - male-Non-science).

So, even though he recalled the entertaining beer-making activity provided by the teacher, he couldn’t add much more to his experiences in the science classroom. His recollections were more of written exercises that did not hold his attention.

Other interviewees, namely Xiaoli and Krishna were both non-science students in Year 13. They both clearly recalled that they enjoyed junior science very much. Surprisingly, both did not pursue it in secondary classes for specific reasons. This is what Xiaoli and Krishna said when interviewed about their Year 9 and 10 science experiences:

“So, we did some small explicit tests, we did them outside of class. I absolutely love like the experiments we did, the elephant toothpaste thing that was one of my favourite ones, so we did that outside also.” (Xiaoli - female-Non-Science).

“We did experiment on animals and stuff like that. Like lungs of lamb and stuff like that. Yeah because I can remember in Year 9 we did the lungs one and it will tell like how it breathes like normal and stuff like that.” (Krishna - Male -Non-Science).
Yet, when questioned why they did not pursue science subjects in Year 13, the answers were optimistic and clear. The reason given for not continuing with science for Xiaoli was her definitive career choice. She clearly articulated that she intended to follow a specific pathway like her sister in business studies. Xiaoli felt that business studies and management was her forte. Even as a Year 11 student she had enjoyed science and performed very well in various science assessments, but she had strategically decided against taking science subjects in Year 13 because of her passion for business studies and the arts.

The reasons for not taking science were clearly voiced by Krishna because science was a hard subject. He said that he had dropped science in year 13 as he found the subject content difficult to comprehend and was also unable to cope with the large amount of subject matter. He was therefore unsure that he would gain credits from any of the Year 13 science subjects and dropped them over easier subjects where he felt he could gain credits without too much effort. He was also emphatic that his teachers had advised him against taking science due to his inability to cope with the content and problems of gaining credits.

In contrast to the several positive experiences of most of the respondents the experience of Ritika were quite negative. She expressed adverse experiences from her earlier memories of science. She felt that science was never really “intimate” in junior years. Just watching videos and writing was not her thing. Surprisingly, Ritika, continued with science despite her earlier indifferent experiences. Ritika’s choice of continuing with science is yet again linked to the theme of external factors playing a vital role in decision making. Career pathways dictated her science option. She needed science to follow her dreams of becoming a doctor.

In general, engaging activities provided by the teacher influenced learning and the enjoyment of science in years 9, 10 and 11. However, it did not necessarily always result in students pursuing science. This is evidently supported by yet another student who liked science but did not pursue it later. Here is an excerpt from a non-science student, Fabida, who had enjoyed and understood science from effective student-teacher interaction and said:

“We did a physics experiment; our teacher was involved in it as well, so it really helped us understand. You need to feel the experiment It was making structure and get weight about 200 grams.” (Fabida – Female – Non-science)

These feelings of Fabida who enjoyed hands-on activities were likewise reiterated by Iosefina who said:
“I feel like I wanted to do science subjects because of those experiments that interest me and learning about science is interesting and also the knowledge behind science is fascinating.” (Iosefina – Female-Science).

This trend of finding years 9 and 10 interesting was echoed throughout the interview by almost all the participants who appreciated science as long as the pedagogy and the content delivery sustained their interest. These included a wide range of various hands-on experiments from making sherbet to balloon explosions, use of dry ice, dissecting animals or animal parts and building towers or being involved in group discussions and collaborative work as variously described by the participants. Field trips, videos and out of class collaborative activities were remembered with keenness as they were memorable experiences.

Boring content, long periods of teacher-talk and transmissive pedagogy were common examples mentioned by students like Fredrick, Ritika, of how students became disengaged with the subject. Writing long essays, answering lengthy questions and "too much writing" were often cited as reasons that put the students off from being interested in science. The overall results from this theme provided clear evidence that almost all students enjoyed science in junior school. This enjoyment, however, was not related to taking science in the final year of schooling. The reasons for choosing options were variously influenced by several external factors as discussed in the next section.

**Theme 2. External factors that influenced decision making**

The interplay of numerous external factors emerged as a strong theme that played a vital role in participants’ opting to pursue or not pursue science at senior levels. These external factors that drove students in their subject choice included the influence of parents, family members, perception of rewards that were financial, the need to gain NCEA credits and preference for subjects as university requirements towards career pathways.

The impacts of parents, family members and friends were quite diverse for each student. Friends were clearly not a major factor in this decision-making process for most of the interviewees. While they talked about subject choices with friends, discussed their subject content with peers, choosing a subject because of the friends taking the same was not reported by any of the participants.

Some of the students said that parents had a major role in advising them about subject choices. Ritika and Marekerita, for example clearly mentioned the impact of their parents on their decision making. Both, of these students had parents who came from a science background.
and were in science careers. The expectation of the parents was that their children would also continue with science and science careers. Along with expectations, both students expressed that their parents were motivating factors and role models in their lives. This is what they said:

“I think my parents played a huge role in my subjects because as past history my parents have done science in high school and continued into university, so they had the same expectations of me on picking up these subjects and taking it throughout university and doing something as a career in like science.”
(Ritika - Female – Science)

“Yeah my mum studied human biology when she was my age so that actually motivates me. For me when I was little, I always wanted to be a nurse.”
(Marekerita - Female – Science)

While parents with a science background may well have had an influence as seen above, many parents who are not necessarily from a science background, could not advise their children but often aspire for their children to pursue science or support them indirectly. The parents of both Apelu and Aroha are typical examples. Both Apelu and Aroha were very driven in their attitudes from junior classes to pursue science in Year 13. These science students explained that while their family members supported their individual decision making, they had little or almost no role in their decision making for the following reasons.

“When I got to Year 11 my dad said that if I was to take science. I would get more opportunities of getting a job and a higher job with a lot of money. Because I’m staying with my uncle my parents are back in the islands. They don’t really know anything about science to be honest. I am like the first one to take science in my family so all they do is tell me that whatever you are good at just keep on doing it and yeah.”
(Apelu – Male-Science)

“Well my parents haven’t been in university they have only been at courses. So yeah it was pretty hard because I never had their support or their knowledge and background in university, so I had to find it myself. They had a little influence.”
(Aroha – Female- Science).
Apart from family members being an important external influencing factor, the aspect of remuneration was a strong motivational factor for some. Fredrick and Xiaoli, both non-science students, described how they had categorically selected non-science subjects based on the careers they would be following. Fredrick was motivated by his brother a carpenter to get into a trades profession in carpentry as there was a considerable amount of money that could be earned. Ritika also believed that science careers paid well and said:

“Yeah so like it is actually believed that things to do with science have a higher pay so I think people are influenced by having a higher pay in the future to help them survive the everyday life and stuff.”  (Ritika – Female – Science)

For Xiaoli, a career in business had motivated her to choose non-science subjects. While Xiaoli was under no influence from her parents, her older sister, a business graduate at university was her motivational factor, inspiring her to get into business studies.

For several students (Apelu, Ritika, Fredrick and Xiaoli) the remuneration in their respective career pathways were external factors that had influenced their decisions to choose subjects whether science (Apelu and Ritika) or non-science (Fredrick and Xiaoli).

NCEA credits were another external factor that formed an important part of this educational journey for a significant number of students. This was because many participants were clearly following a pathway leading to courses at tertiary institutes or university. Participants chose definite Achievement Standards within each subject that would support them with the entry requirements into University Entrance in courses such as Nursing (Marekerita) Engineering (Apelu) Health Science (Aroha and Ritika), Business studies (Xiaoli).

Talia, who was very clear about working in the community in events management had selected subjects such as dance and drama that related to building up her confidence towards her career. She reiterated that credits from academically driven subjects were not a very important criterion for her. She wanted to enjoy the subjects that were close to her heart.

Krishna had calculated his credits requirements quite strategically. He did not take science in Year 13 because of difficulty levels but still intended to pursue environmental science at University by gaining entry requirements through a foundation course. Credit requirements barred a few students from pursuing their desired subjects in science. For example, in Krishna’s case he required a specific number of credits to gain University Entrance. He was confident that if he took science, he would not pass the Achievement Standards in that subject. So, to gain credits, he had dropped science in favour of other subjects, which he perceived to
be easier, where he could gain credits. Curriculum demands, difficult concepts and ineffective curriculum delivery were cited as external factors that prevented some participants from pursuing science.

For most participants interviewed, their personal decision to take science or drop science was evidently driven by their personal goals. Academic self-concept and intrinsic motivation were narrated as important drivers by these participants and are discussed under the next theme. Yet for a few, guidance from parents and other family members formed an important influence regarding decision-making.

They all had a clear idea about their interests, capabilities and the jobs they were likely to pursue. Stringent subject requirements for future careers or credit requirement to gain entry to university undoubtedly dictated students’ subject choices.

**Theme 3. Individual self-concept**

This theme focuses on how adolescents gauge their own abilities about how they can succeed or fail in given subjects based on their personal experiences. These abilities are developed as a result of self-perceptions or self-evaluations made by an individual of their own cognitive capacities. They are based on personal understanding or not understanding the content of the subject, success or failures in assessments and confidence developed during the duration of course.

Astonishingly the interviews of all 10 participants revealed that they were clearly convinced about their goals to follow trajectories in choosing subjects at Year 13 that would lead them on to desired careers. There were no exceptions among these 10 students. All non-science students were focussed on diverse non-science careers. Similarly, science participants namely, Ioesofina, Ritika, Marekerita, Aroha and Apelu were all keen to get into careers in science such as, nursing, Bio-Med, optometry and physics. They categorically persevered taking science subjects against all odds. Some of these odds described by them included difficult content matter, boring topics and poor pedagogical practices. One of the student's Krishna for example had serious aspirations to continue with science even though science was problematic at school. Given his positive self-concept he had categorically worked around the problem. Krishna did not take any of the sciences in year 13 and he said this at the interview:

“I don’t want to do science this year because I know it will be difficult a lot and that is why I decided not to do it.” (Krishna Male – Non-science)
Yet to circumvent the issue Krishna was pursuing environmental science at University by planning to complete a Foundation Bridging Course. It was interesting to observe that Krishna had back up plans to continue with his desire to go into a science related career in spite of science not being his Year 13 subject choice. This implies in some way the failings of our school system, which results in students having to circumnavigate the content issues of the curriculum. Krishna was keen to get his UE by gaining the required credits from academically less dense subjects. He then had plans to follow his dreams by getting into a course using a bridging course during the holiday period.

Students like Ritika, who found the content in chemistry and biology difficult to comprehend and voiced the opinion that the teachers were not delivering the lessons in a way suitable for all students, used YouTube videos and google searches to teach herself. She was unequivocal about her ideas on pedagogy in the science classes. She felt that students were not encouraged to ask questions and normally kept quiet in class, so the teacher carried on, believing that all students had understood the topic. Concepts were often not explained clearly and, as a result there were huge gaps in her knowledge. She overcame these issues by spending extra time on learning by herself. A clear vision of following her dreams to continue with health science to succeed as a doctor motivated Ritika to pursue with year 13 biology and chemistry using online tools even though she was struggling with the teaching and learning in class.

Students like Talia who were extremely happy with the non-science subject selection and performed well in those subjects justified their feelings about science.

“… but at some point, it kind of got lost. Yeah the subject kind of got lost because I don’t even remember what we done in science. because science is not really a subject for me.” (Talia – Female – Non-science)

Physics clearly stood out as a difficult subject for most participants including Ritika who had dropped it after Year 12 and Marekerita, who felt she never really understood the subject. This is what she said:

“I don’t like physics. For me I just think it is hard and I never learned it.”
(Marekerita – Female - Science)

While other science subjects like biology and chemistry were popular physics was considered difficult by most. Only 1 out of the 10 participants, namely Apelu, expressed his liking for
physics. His academic self-confidence was high, and he was motivated to pursue engineering at University given his good results in physics in both years 12 and 13.

Another participant, Xiaoli, who had performed extremely well in science at Year 11 and scored top grades in her assessments was encouraged by her science teachers to pursue science in Years 12 and 13. Xiaoli described how she had experienced great success especially in her role in a business enterprise activity at school. She had also seen her sister excel in a business degree course at university. Xiaoli, felt that her business acumen was better and therefore decided against science in spite of the encouragement provided by her science teacher and her own personal academic success.

The theme of self-concept that emerged is quite convincing evidence that students will pursue the subjects that they are confident about, subjects that they like and most importantly, subjects they have selected as a deliberate trajectory leading to a career. Academic self-concept is probably a very important factor that is a vital driver that directs students in their decision making.

**Theme 4. Interest in Science**

This theme provides an overview of how all students both science and non-science perceive their interests in science. Irrespective of whether participants took science or not, there was clear unanimous agreement about individual interests in science. All the participants clearly indicated that in their personal opinion, science and technology played a very important part in their lives given the present prevalence of apps and technology. A number of students from a non-science background admitted to taking a keen interest in listening to their friends talk about science even though they were not taking science subjects. While they all strongly believed that science was important in life, and this was reiterated several times during the interviews, they did not see its importance as a learning subject. This is what two of the non-science students had to say.

“Even though I’m not a science student and I don’t take science anymore, but like I see it within my friends, the majority of my friends take bio and physics and chem. I think it still is relevant because it is really cool sitting at lunchtime and hearing them talk about the things that they’ve learned. I would be like talking and talking about a tree or something and they would explain what they have learned about that tree or how it is grown.” (Talia-female- non-science)
“So, I really like science I watch documentaries and many research histories and stuff all by myself just for general knowledge, but somethings in science are sort of boring in a way when the teacher keeps repeating over and over the same subjects.”
(Xiaoli- female- non-science)

Other non-science students explained how important it was to know about science, to be able to understand about the use of different technologies and solve environmental and global problems through science.

Many of the science students aptly explained that science was important in life but stressed the fact that school science did not prepare people for real life problems. The use of technology, wi-fi, cell phones, cars, glass TVs were variously given as examples by different participants as being associated with science and technology, important for the society to use but it was not necessary as consumers to have know-how about how they actually worked.

What stood out from the various conversations at the interviews was that science as a curriculum subject was neither motivating nor as interesting as some of the other subjects. With the move from junior to senior school, the interest in science dwindled as less experiments were done, the content became extensive and very dense, and did not always relate to real life scenarios. Difficulty levels in understanding science concepts were cited as reasons for not taking science by three of the non-science students. Also, two of the Year11 science students, Xiaoli and. Talia, who had both done extremely well in science in previous years, did not choose to take science. They both said that they had a keen interest in science as evident from comments made by them earlier in this chapter. Both had been encouraged by their science teachers in Year, 11 to continue with science in their final years. Yet, they felt that science was not their thing.

This endorses the observation that interest in science did not necessarily form a crucial factor in influencing students to opt for the subject in senior school except in the case of Apelu who absolutely loved physics and raved about his interest in the subject and his motivation for taking it

4.5 Summary of findings from both quantitative and qualitative data
A fairly detailed picture emerges from the complete sets of both the quantitative survey data and the qualitative interview data. While there seem to be several areas where the two data sets complement each other, there are several items where the data information tend to show some contradictions.
Examples where the two data sets complement each other include the keen interest in science in junior science classes. There is a strong co-relation between subject choice for studies and career pathways in both sets of data. Career choices seem to dictate the selections made at secondary school, as they form the pathway to university or technical institutes or community jobs. Moreover, interesting teaching and learning experiences result in positive attitudes among learners. This came across in both sets of data.

Among the contradicting aspects of the two sets of data, responses to peer and family influence, were different as seen from the graphs from what was expressed by the participants in the interviews.

Self-concept and self-determination were some of the major drivers that led some students to aim towards success in science. In spite of not enjoying science, not gaining credits or not coping with the content knowledge, continuing to grapple with the subject via the use of you tube videos, self-taught lessons and bridging courses at University indicates the strong self-determination of these students. These concepts will therefore be analysed and examined in detail in the next chapter.

4.6 Conclusion

While this chapter has presented all the raw findings formatted in a tangible way to understand student voices in decision making, it is still unclear whether some factors are more dominant than others in this major decision-making process. Several of the findings from both data sets corroborate the literature reviewed earlier. However, there seems to be a trend towards independence among students in their decision-making irrespective of family influence and all other external factors related to classroom experiences. Some student voices from the qualitative data also indicated that the importance of being in a happy state of mind is more important than just the financial benefits of choosing subjects or careers. Yet there were others for whom jobs and rewards from salaries were of prime importance. The idea of doing different jobs in a lifetime was another key idea that came through in these interviews. Many of the participants felt that they would probably not continue with just the one job that they wanted to do at present. A discussion with reference to the literature and the interpretation of these findings are detailed in the next chapter.
Chapter Five: Discussions of findings

5.1 Introduction

This study has found that we are currently faced with the issue of declining enrolment numbers in secondary science in numerous countries around the world. The causes and various factors behind this decline have been examined in both the literature and through the voices of a cohort of the Year 13 learning group within a secondary school in South Auckland in New Zealand.

The purpose of this chapter is to interpret and describe the significance of these student voices obtained during the study. The discussion provides an explanation of the results with reference to both the students’ expression of opinions as well as the results referenced in the literature. It offers a suggestion about how these results could be applied to understand the issues concerned and promote an increase in science enrolment numbers in the future. While the solutions suggested sound herculean, they are central to solving the present issues of the scarcity of students applying for traditional science subjects in secondary schools. These directives could possibly support and increase the future of the STEM workforce. The chapter concludes with a possible hypothesis that could be further applied to subsequent research in the future to enhance student enrolment in secondary science classes.

5.2 Answers to key questions

The key questions referred to at the start of the research study are re-visited and an attempt is made to provide answers to these questions through the interpretation of student voices. References to the literature along with these answers enable us to think critically about the underlying issues on the four questions posed. Likewise, it re-examines how best they may be resolved in the future. The discussion also explores possible improvements that could be applied in the education sector taking into count the findings during this study.

To begin with there is clearly no single answer to any of the following questions:

- Why do students select science in secondary schools?
- Why do students refrain from selecting science in secondary schools?
- What attitudes do students hold towards science?
- What factors interplay and influence this decision making?

Each of these questions elicit possible answers, which need to be understood in depth to appreciate the problem. Given the wide spectrum of answers to the above questions displayed by the results from both the survey and the interviews, it seems the current educational system
requires a paradigm shift. The following sections look at some of the significant conclusions that emerge from the study, and the possible ways that they may be addressed from the researcher’s point of view.

5.2.1 Multi-factor interplay
Firstly, an analysis of the results from both quantitative and qualitative data sets clearly show that there was no single factor that could be attributed to any of the individual’s decision making in the selection of science or non-science subjects in the final year of schooling. Parental and family influences, career pathways, interest in science, subjects required for tertiary studies, difficulty level, self-determination and academic self-concept are some factors that had varied degrees of influence in the participants’ decision-making process.

Decision making appears to be a complex process as inferred from the results of this research study. This deduction is consistent with several of the research studies over the last two decades and is therefore not very surprising. The results from this study in fact resonates with research findings in the United Kingdom (Osborne, Driver & Simon, 1998) in the USA, (Costa, 1995; Jones, Howe & Rua, 2000) in Sweden, England, Australia (Lyons, 2006), as well as in New Zealand, (Hipkins, Roberts, Bolstad & Ferral, 2006). All the above researchers have also shown an interplay of several factors in this process. This concurs with the present findings. The current observations are therefore not highly unusual.

This multi-factor interplay in decision making is discussed with illustrated examples from the study, along with possible resolutions.

5.2.2 Family and parental influence
A second noteworthy observation made was regarding the external factor of family members’ influence on participants’ decision-making. Even for those students who had personal desires and clear intentions of enrolling into science to follow science related careers such as in biomedical jobs, nursing, environmental science or engineering, the family members seemed to have an influence alongside the participants’ personal intentions. Siblings and parents played an integrated approach (Lyons, 2006) to the decision-making process of several of the participants interviewed during the study. For many, whose families played little or no role, the individual’s personal intentions towards a desired career then formed the catalyst in choosing specific subjects.

However, staunch family support for these students to continue with their personal desires was continuously cited as a positive factor by the students. Statistical survey results however,
showed that many participants felt no family influence whatsoever. About 40% of both science and non-science students’ responses indicated that their families had little influence on their decision making. This is understandable as many young people are very independent about their academic career pathways these days. Also, parents who were actively involved in their children’s primary and intermediate school work were not totally familiar with the current NCEA curriculum requirements or the NCEA assessments. Nor were they well versed with the various flyers updated online by the NZQA, or with the large number of science career choices and pathways that were available as they themselves did not have a science background. Home-school partnerships were not always robust. These statements were mentioned by the participants who explained why their parents did not have much of a say in their final year subject choices.

While such home-school partnerships are very strong in the early years of schooling, they become limited, often restricted to a few brief parent-teacher evenings in the secondary school set up. Yet, the literature is unequivocal in asserting that parental involvement makes a substantial difference to students’ educational accomplishment (Epstein, 1995, 2001, 2005, 2018; Biddulph, Biddulph & Biddulph, 2003; Bull, Brooking & Campbell, 2008; De Silva, Khatibi & Azam, 2018). It is therefore important for parents to be involved in different ways such as supporting or guiding students directly and indirectly and encouraging adolescents with their academic aspirations.

One way to enhance this family support for all students is to build strong and well planned home-school partnerships (Epstein, 1995; Bull, Brooking & Campbell, 2008; Epstein, 2001) embedded within whole school developmental plans. Information evenings about NCEA at schools are often tedious. Given the time constraints, these one-off sessions within an academic year do not always provide the parents with enough support to make meaningful contributions to their wards’ educational decisions.

To make a success of home-school partnerships, informal sessions with parents, with simple, concise and easy materials regarding academic requirements, career pathways, possible industrial training programmes relevant to the needs and skills of the child, must be provided to the parents all through high school years. This would help to bridge the massive gap between the child’s academic requirements and the parents’ knowledge about the academic happenings at school for students in years 9, 10, 11, 12 and 13 as each academic level is very different from the other. Such sessions and partnerships need to be strengthened from the early years of secondary schooling rather than just in the final years. A step-up with information in
each academic year would allow parents greater familiarization with current educational and societal conditions.

*NCEA & the Whanau* for example is a classic information programme workshop designed for parents to get to grips with the basics of the NCEA system. Similar science and STEM orientation workshops would allow better parental engagement towards goal-oriented future focussed science programmes. This may increase the number of students entering science in the final years. However, for this to be successful parents and guardians need to be fully involved in the processes. A review of recent research (Henderson & Mapp, 2002) advocates that all secondary schools need to actively promote more workshops and meetings for parents to augment this parent involvement. An orientation programme with service providers that enables parents to understand the needs of the learners to take subjects leading to the growing market of STEM jobs would allow parents to have better dialogues with their children. Such involvement between students, their parents and the community along with the school, would boost science enrolments as suggested by Henderson and Mapp, (2002). The OECD (2016) report on the PISA (2015) assessment framework, strongly advocates for parental involvement as they are important stakeholders in this educational system.

So long as parents are recognised as equal partners making potential contributions to their children’s decision-making, they will feel valued (OECD, 2016) even if they did not come from a science background. It would allow them to take a keen interest in their children’s future if they were equipped with the right information. For many parents the meetings with science teachers are often one-directional, where parents only hear the teacher speak about their ward’s progress. Strong home-school partnerships are multidimensional and can increase awareness towards community needs (Bull, Brooking & Campbell, 2008) through constant two-way communication. These include positive conversations, frequent emails, telephone calls and texts to enable parents to monitor their wards, have positive conversations and be made aware of where the children are in their academic progress continuum.

To make parents familiar with the latest needs in the field of science education it is important to brief them regarding the current trends in the community. This process needs to occur in an unintimidating manner, especially in low decile schools. All parents desire the best for their children. However, it is often frustrating when parents know very little about their children, especially during the least communicative phase in teenage years. Having parents as partners in the education journey of their children would lead to greater student success. This is strongly endorsed by De Silva, Khatibi and Azam (2018) who have shown that parental
involvement has a lasting correlation with students’ intrinsic and extrinsic motivation to learn science, particularly in home-based parental partnerships.

5.2.3 Career pathways

A third observation which had a clear bearing on decision making regarding subject choices in this study group was the determination of future vocational prospects leading to successful careers. Among the various factors, subject choices were deliberated to a major extent on specific jobs that participants were intending to follow in the future. In this study, 9 out of the 10 students interviewed asserted that their subject options were picked based on desired career pathways. There is also supporting evidence from statistical analysis in Figure 14 which illustrates that a considerable percentage of the survey population (N=102), including 85% of science participants and 67% non-science participants agreed to varying degrees from strongly agree to slightly agree about the relation of subject choices to career prospects.

In fact, science related career pathways seemed to be of primary importance in decision making for those interviewees who had selected science options. Likewise, students who did not take science were also very strong in voicing their opinions about clear visions of non-science jobs. Both sets of respondents were confident that their subject choices would ultimately lead them to their preferred careers. Such confidence in decision making is supported by Bøe, Henriksen, Lyons, and Schreiner, 2011. It establishes that the ‘directed trajectory’ pathway described by Cleaves (2005) was adopted by these participants. A directed trajectory is when students develop specific career commitment at very early stages during their school years and continue with this stable career choice into their final years (Cleaves, 2005).

Many of the participants who had taken science subjects against all odds such as difficult curriculum, transmissive pedagogy or dense content were still confident to achieve the desired credits with extra tuitions, internet-based YouTube videos and study web links. Such participation to continue with science despite several issues, agrees with the findings of Bøe, Henriksen, Lyons, & Schreiner, (2011) who provide substantial evidential support to show that decision making towards participation in given subjects, in this instance, science and technology, among adolescents in late modern societies is driven by self-determination to achieve. Participants clearly exhibited personal agency in career pathway development processes; an idea reinforced by Lent, Brown and Hackett (1994). The goals of getting into a definitive career played an important role in this self-regulation of their behaviour.
To enhance the entry into science subjects, it is ideal for schools to provide students with solid career counselling which is often insufficient in many schools. The literature also points to increased success of science enrolments in schools that provide their students with outstanding career and guidance counsellors (Hipkins & Bolstad, 2005). Many students often link science subjects to a few limited careers either with forensics, medical or the engineering field. For example, the students interviewed during this study spoke very little about the availability of extensive career guidance and the vast array of science jobs. Taking science was linked mainly with biomedical or engineering jobs.

The concept of numerous career options available these days in science technology engineering and mathematics is often not always known to all students in Years 9 and 10. Career expos as often provided by schools via external providers may provide brief insights to such jobs in the final year of their schooling. The need to have individualised career counselling for all students, based on their aptitude starting from junior years is vital. Guidance to Independent Educational Programmes ensuring that specialised counsellors are highly visible to all students, all through the year and at all year levels will ensure an equitable programme (Borders & Drury, 1992). Such initiatives would enhance student uptake into science pathways in senior years.

The key focus that schools need to aim for is the idea of career counselling should occur at early years as well as the later years. This is because, while students are still making up their intentions of subject selections for the final years of schooling and planning for future jobs (Borders & Drury, 1992) they need to know what is available to them in the real world along with the trends in the job market. In addition to home-school partnerships, career counselling would be a strong flagship advising both parents and youngsters towards STEM pathways.

5.2.4 NCEA Assessments

A fourth observation made in this study clearly pointed to the large number of assessments that students need to pass to enter the next level of study. The assessments, related credits from the Achievement Standards in each subject in some ways directed decision making.

For example, choosing subjects that would lead students into science career pathways, came with a price tag. These included the prerequisites of credits in Year 11 to enter Year 12 and subsequently from Year 12 to enter Year 13. To pursue a given science subject like chemistry, biology or physics students needed a specific number of credits in each of the given subjects.

In general, if students did not pass the required number of Achievement Standards in each of the specific science subjects, they were unable to continue with Year 13 science subjects of
their choice. Credits from assessments, thus became the stumbling block for many students. This was recorded as a major factor for not choosing science by some of the participants.

The credit requirement for continuing with specific subjects in Year 13 is almost mandatory in all schools. The assessments are often content driven with a major focus on literacy as pointed out by the respondents during the interviews. Participants also said that the assessments were very often knowledge based than skill based. The assessments did not seem to appeal to most students as they had very little relevance to real life.

Currently teachers are obligated to complete the syllabus and responsible in achieving to school targets. Similarly, students are expected to pass the NCEA Level 1, in various Achievement Standards (specific topics) as prerequisites if they are to enter Year 12. This is further continued into the Year 13 science subjects. The NCEA Level 1 pre-requisite credits to enter Level 2 and the follow-on requirements to Level 3 thus become the decisive factors for the students in pursuing science.

Unfortunately, rather than practising innovative methods of teaching to the curriculum, teachers tend to teach more and more to the assessments, and continuously administer tests, in order to complete the syllabus, provide progress results to parents, and enable students to pass the external examinations. In this process there seems to be an abundance of tests and examinations. It is these assessments that can frustrate the students’ desire to pursue with science in the final years of school. Both students and teachers are caught up in these assessment conflicts. If assessments do not carry credits, they are not taken seriously by students and perceived as a waste of time. As a result, feedback from teachers on the formative assessments have little validity. In a very recent report, Middleton (2018) states that "teachers/kaiako and educators have expressed concern that NCEA achievement standards have effectively become the curriculum for most senior students in Aotearoa New Zealand." Middleton (2018) expresses concern that while the NCEA was designed to be a progressive curriculum to engage students teaching practices in schools were not implemented as they were originally intended during the development of NCEA.

While we are noticing a smaller number of students taking up science, we are not doing much to make it easier for them to enter these subjects. The stringent requirements of a definite number of credits for entry into Level 2 and 3 NCEA classes must be minimised or the assessments must change to reflect students’ needs to increase participation, otherwise issues of inequity will continue to escalate in New Zealand and science enrolments will continue to dwindle. This can be achieved if we continue to build on the existing interest in science.
evidenced in the results of Years 9 and 10 all through Years 11, 12 and 13, by keeping the curriculum engaging and minimising assessments.

To ensure that we continue to have more students continue with science in Years 12 and 13, we need to ensure that the NCEA assessments are made more appealing, authentic and practical as reiterated in the OECD (2003) report. Assessments could include science projects where students work collaboratively with industry and the community to produce folios, presentations or products. These assessments need to relate to the needs of the century, rather than being content driven and dictated by examinations and credits. The curricula in Years 11 to 13 do not appeal to all adolescents. This is largely because the curriculum is very often difficult and dense. Content driven assessments also discourage students from taking science.

While interests, curiosity and inquisitiveness tend to peak at the ages of 14-15 years during Years 9 and 10 as evident from both the statistical results of the survey and interviews, supported by a wide range of the literature (Lyons & Quinn, 2010; Osborne, Simon & Collins, 2003), the interest seems to disappear at the end of Year 11 for many students mainly because of the dual combination of assessments and the dense content of the curriculum.

5.2.5 The curriculum

A fifth observation that emerged from this study is the role of the present curriculum which students perceive to be dense and content laden. This is mirrored by the reflections of similar age group children in the UK as detailed by Osborne and Collins, (2001) in their research findings. The sudden obstacle of increased curriculum content in NCEA Level 1 from the easier junior science programmes of Years 9 and 10 proves to be tough on students. A decrease in the variety of hands on activities presented as compared to those in earlier years also results in loss of interest (Jenkins & Nelson, 2003) as mentioned by the participants during the interviews. Subjects like physics and chemistry were often cited as being difficult, an observation reiterated by Osborne and Collins, (2001). Certain topics within each of the sciences, such as genetics, and specific Achievement Standards stood out as being difficult to pass.

Students also found many of the science concepts difficult to comprehend like atomic structures in chemistry. Teachers were unable to provide individual assistance or extra time within the class time to help individual students comprehend these difficult concepts of the curriculum as they themselves were hard pressed to complete the syllabus. Such findings have also been established by Osborne and Collins, (2001), Koul and Fisher, (2002) and Hart, 2002. In many cases, students persevered with their science courses with extra coaching lessons and
private tuitions in order to do well in the examinations. As mentioned in the interviews, students also resorted to self-study via YouTube lessons and study links on the web to overcome content difficulties.

Students must be provided with extra in-class time to overcome this need for extra studies or tuitions outside of school’s learning hours. While many schools provide lunchtime classes or after school lessons to help with the academics, such facilities are not always available in all schools. On the other hand, given the home, sports and church commitments of many youngsters these after school sessions are not always convenient.

The participants felt that they needed to be provided with supporting online resources of personalised lessons through blended learning or online learning management systems that needed to be well established as a common practice across all disciplines. These were not always available. Digital learning is probably one of the important steps needed at present to allow students to get to grips with the difficult curriculum if the curriculum continues to stay the same. Blended learning, with engaging resources maybe a probable answer to support the learning needs of the students. However, issues of inequity often arise in respect to the quality of resources and funding for digital expansion within different schools. For students who do not perform well under examination conditions it is imperative to re-think not only changes to the curriculum but also to the assessment techniques and systems that are currently in place.

Rather than underpinning the significance of the nature of science, its importance in building citizenship values, imbibing a project based/problem based/ inquiry-based STEM approach to learning, the curriculum forces the participants to be restricted to an assessment pathway that is rewarded by the credit system. The curriculum, to a large extent along with credit dominated assessments, are the main culprits for diverting and steering the course of engagement and participation in senior years. The demanding content laden (Osborne, Simon & Collins, 2003), the NCEA pre-requisite credit requirements, over testing as in class assessments and examinations thwart the continued engagement of even the most avid of science learners during these important secondary years.

There is a clear indication for the need for changes in the curriculum if we are to make it attractive for students to pursue science. Considering the above issues what emerges is that science is clearly not selling itself to the extent of being an attractive option for all students. What is important for policy makers is to recognize that science is an iteration of understanding. The philosophy should be to increase greater participation in science for all students up to Year 13 by providing a curriculum that is interesting, attractive and innovative.
If the nature of science was better understood by the students, more of them would go on to take up science. The curriculum needs to focus on developing citizenship values, increase social awareness of current socio-scientific issues (Driver, Newton & Osborne, 2000; Kolsto, 2001), enhance scientific literacy and promote the utilitarian purpose of science (Bull, Gilbert, Barwick, Hipkins & Baker, 2010). These needs are of primary importance, as elaborated in the literature. If an authentic and engaging science curriculum lends itself to promoting the utilitarian purposes and citizenship building purposes of science learning, it will automatically lead to greater enculturation, increased scientific literacy (Jenkins, 1999, Bull et al., 2010), and attract more students into science subjects, and later to jobs currently available under the STEM umbrella.

The current nature of assessments and stringent credit requirements can seriously hamper academic achievement. The resulting domino effect influences the student’s academic self-concept decreasing their interest in science. (Guay, Marsh, and Boivin, 2003; Shavelson & Bolus, 1982; Bong & Skaalvik, 2003). The theoretical textbook curriculum replaces the experimental and practical experiences of Year 9 and 10 in the senior years of school, thus, causing the loss of interest and excitement in science.

The curriculum for present times needs to be transformed reflecting more STEM activities, supplementary hands on experiments including projects, presentations and portfolios. If we are keen to attract more students into continuing with science the curriculum should include collaboration between students and industry to work on problem solving through activities linked to real life scenarios.

As explained earlier, there is an urgent need to move from knowledge-based assessments to skill-based assessment practice including the need to increase awareness of socio-scientific issues that are vital for both personal and societal decision making. If we continue to follow teaching and testing according to the present system that often has little or no bearing to real life, we will continue to alienate many students from taking science. Especially those who have had a curious interest in science and had enjoyed science in the early years.

### 5.2.6 Participants’ interest in science

A sixth observation that resonated with both data sets was the keen interest students had in science during their junior classes, in both Years 9 and 10. The majority of the participants interviewed indicated that they were engaged with science in the first two years of their secondary schooling. The key reasons for this interest and engagement was the active involvement in science through a variety of hands on activities. Sadly, this interest waned in
Years 11 and 12 leading to the decline in science enrolment. The reasons given for the decrease in interest in secondary sciences in Year 11 was the influence of the examination regime along with sudden increase in the curriculum content as compared to Years 9 and 10, transmissive pedagogy, attempts to complete the vast syllabus in the given time, and a lack of engaging activities related to the real world. These observations are also concurrent with the existing literature (Lyons & Quinn, 2010; Osborne, Simon & Collins, 2003). The concern is, while more students are required to take science to step into the STEM work-force we are not addressing the issues of how we can continue this interest all through Year 11, 12 and 13. All the above reasons are validated, and students cannot be held responsible for this decline.

Even though 50% of the interviewees had not taken science they unanimously agreed that science was important for the 21st century. Many of the participants not taking science were still avidly involved in conversations about science with their friends during interval and lunch breaks. Some of the participants related how they continued to watch YouTube science documentaries and movies out of personal interest even though they did not take science. These student voices, including from the non-science participants, repeated that science was of interest to them citing examples of global issues like the cleaning of major oil spills by scientific methods, changing weather patterns around the world and their effects, environmental issues, hygiene as a vital factor in our present lives, emerging new diseases, research, and all cited state of the art technology that could not do without science. Unfortunately, however, their interests were not in keeping with subject choices for science.

A waning of interest in science due to a non-engaging curriculum and the continuous disengagement with science pointedly after Year 11, was clearly described as the cause that lead students to dropping science in Years 12 and 13. Disinterest in science was further exacerbated by the prevalence of the boring and dense curriculum of NCEA level 1 which was a big step-up from Year 10. The recurring effects of content laden curricula have already been referred to earlier by Osborne, Simon and Collins, (2003), Jenkins and Nelson, (2005) and several others. Further detachment with science was attributed to a combination of classroom and pedagogical factors, and more credits being available in other subjects that were either subjects of their personal choice or the choice of gaining credits more easily from less academically driven subjects. Students also reported that they had a much wider option to choose other subjects in preference to science from the diverse subject choices available.

The teachers could not be counted as the sole factor in the above process of disenchantment since the same teachers had taught these students in Years 9 and 10 and had continued teaching them in senior years. Yet, the same students complained that from an engaged and
exciting junior science experience they were now faced with heavy duty literacy writing activities, lack of authentic learning activities (Braund & Reiss, 2006) and the pressure to gain NCEA credits.

5.2.7 Motivation
Among the various observations during this study, what stood out clearly as the most decisive factor during decision-making for students was the rationale of intrinsic and extrinsic motivation interconnected to all the above factors discussed at depth. The combination of intrinsic and extrinsic motivation was cited by several participants as the most vital deciding factors for subject choices based on future benefit. The future benefits included following a subject of their passion, strategic value of a given subject, and requirements for university entrance or external rewards. Lyons (2006) has also cited similar directives among high achieving Year 10 students in an Australian study, pursuing science subjects like physics and chemistry in senior classes.

Intrinsic factors were driven by the participants’ self-concept and self-determination while extrinsic factors were driven by rewards in jobs including high pay, status associated with the jobs or following in parents’ desired footsteps especially in high socioeconomic situations. Similar observations have also been enunciated by (Gneezy & Rustichini, 2000 and Lyons, 2006).

5.2.8 Intrinsic Motivation
The process of Self-determination had a leading influence on decision making among all of the 10 participants interviewed. It is a known fact that intrinsic motivation is greatly enhanced if the psychological needs of individual are met (Deci, Vallerand, Pelletier & Ryan, 1991). However, hindrances like negative performance, diminished feedback from teachers, difficulty in understanding content, poor pedagogical methods, deadlines can thwart motivation (Ryan & Deci, 2000).

The determination to pursue science by the participants in this study, who had a deep interest in science subjects was evident from some of the interview conversations. These participants had thoroughly enjoyed their science experiences, understood the difficult concepts of science, tried their best and had scored considerably well on assessments. A combination of competency in science, autonomy to cope with science, high level of performance, added together, played a very important role in their relatedness to liking the science subjects and the obvious reasons for pursuing them (Ryan & Deci, 2000). This is in fact, the basis of the self-determination theory proposed by Ryan and Deci (2000) who postulate that human beings are
proactive and engaged if their psychological needs are satisfied. This positive intrinsic motivation leads to optimal functioning of the individual leading to satisfaction and obviously greater participation in each subject. This enhanced their self-concept. However, for some other students, the hindrances as mentioned above diminished their self-concept. Inability to cope with the content, a boring curriculum and uninteresting pedagogical methods diminished their self-concept. In spite of these obstacles, extrinsic motivation allowed them to pursue with science in the face of all adversaries. These are examined in the next section.

5.2.9 Extrinsic motivation

For a few students, irrespective of whether they took science or not, the concept of rewards in the form of highly paid jobs (Gneezy & Rustichini, 2000), was an important driver in opting for science subjects. So, the students had the expectations of high remuneration from science related jobs such as medicine and engineering and pursued the science subjects in spite of the difficulty level, ensuring that they learnt on their own.

Several non-science participants justified that jobs such as law, accounting, business and future expertise in trade jobs like carpentry could yield high incomes and so science was not important on their list. These observations and findings are strongly supported by Gneezy & Rustichini, (2000) who discuss the importance of monetary benefits as an important rationale for adolescents to pursue their desired line of study.

Non-science options lend themselves to high wage competition and are being preferred over science. The way to attract more students into science jobs needs careful re-thinking and planning. Wages in different science jobs need to be increased if the STEM workforce is to be increased based on the demands of current global needs.

Without a doubt, these attributes of motivation were key factors described by all 10 interviewees, both science and non-science to have influenced participants’ final year’s subject choice selections the most. However, while such strong responses were gleaned from this study group during interviews, it would be inaccurate to extrapolate the same for the entire population. To verify this, one would need to further pursue research along similar lines.

5.3 Conclusion

In conclusion to this chapter, it is evident from the various discussions that several factors are interwoven in this serious process of choosing subjects at senior secondary level. While the motivation to pursue university studies and career pathways has been the most significant one, it is clear that all other factors lend themselves to this process.
While there are several limitations to this study discussed in the concluding chapter, the inferences from these findings reiterate that it is the uniqueness of the child that needs to be at the heart of our education system, guiding our work.

If we can change the science curriculum to hold the interest of students by providing them with real life activities, they will develop a better science self-concept. Interest leads to better performance and achievement. If the intrinsic motivation is sustained specifically during Years 11, 12 and 13 as it was in junior science years it would assist to address the declining numbers in science. Intrinsic motivation would further drive students to step into STEM jobs (NRC, 2003) for the future.

These findings have various implications for teachers, family members, and the school itself, that include the curriculum leaders, career guidance counsellors and the students themselves. The implications of this study need to be understood by the policy makers who are the major players responsible for the structuring and designing of the science curriculum in New Zealand.
Chapter Six: Conclusion

The factors that influence students’ decision making have been very different for each student in the cohort studied, even though this research has explored only a few of the factors that primarily influence decision making. There exist many other factors including gender differences, socio-economic conditions, physical facilities, modern learning environments state-of-the-art laboratories, discipline of the school, single gender schools, use of innovative digital technology and ethnicities of the students. These factors have not been explored. In fact, each of these factors has a different role to play in the process of decision making as understood from various interview discussions. However, from the limited study carried out, a few key valuable ideas have surfaced. This chapter concludes the study with the following sections.

Section 6.1 identifies possible implications for practice reflecting on the research questions and findings. Section 6.2 describes the limitations of this study. Section 6.3 recommends possible areas for future research studies. Section 6.4 presents the concluding comments.

6.1 Implications

What has clearly emerged from the findings in this research is that irrespective of whether students have a genuine interest in science in Years 9 and 10 or have a very sound science self-concept, they are unlikely to pursue science if other subjects are more attractive. Although many students continue to take an interest in science, outside the classroom in peer to peer conversations or watching science movies, personal interest in a subject was the main driver in subject choice decision making for several students. A clear challenge to the policy makers and teachers is to provide a curriculum and activities that makes science more interesting to teenagers especially in Year 11 when decision making is vital.

Furthermore, there needs to be a conceptual change in the basic teaching strategies employed in the classroom. The teacher’s role as a facilitator needs to be strengthened. The cultural capital that students bring into the classroom needs to be recognised. While this is a significant challenge, using students’ cultural capital to increase participation and engagement will undoubtedly lead to greater success in drawing students into science. Time constraints to complete the curriculum and syllabus needs to be reduced. This is the crux of the problem. In saying this, the government also needs to rethink its policy in terms of increasing investment in education. To attract, retain and develop science teachers; needs to be a national priority (OECD, 2005).
The study also recognised that students are not necessarily following science subjects after Year 11. Thus, Year 11 is of paramount importance as it is after this year, we tend to lose enrolments in physics, chemistry and biology because these are often dictated by the entry credit requirements. The crucial period of Year 11 when decision making begins, needs to provide far more attractive courses than those currently on offer. Further, to allow greater thinking time for adolescents during this decision-making process in the final year, it would help if credit requirements were lowered for Year 12 science subjects, which would encourage more students to participate in Year 12 science. It is also imperative that Year 12 science offers more engaging topics relating to the real world, that could encourage more students into future science.

The topics included in the science syllabi in Years 12 and 13 have remained the same for several decades. Content heavy subjects offered by the curriculum are not easily handled by adolescents, many of whom, will inevitably choose less academically challenging subjects. It is the curriculum to a large extent that is driving away interested students from science. To allow more participation in science it is necessary to have attractive science courses that are different from traditional courses. Alternative hands-on and professionally resourced skill-based STEM courses, with equal credit opportunities, must be offered alongside traditional courses. If these courses provide students with real world authentic experiences that are more meaningful and attractive than book work and theory, more students would be attracted into taking science.

While students often have access to an academic counsellor in Years 12 and 13 who provides information about tertiary courses and pathways, it is important to have more counsellors at Year 9 and 10. This would mean students could be guided and encouraged from the very early years to view the varied possible career pathways related to science. The role of academic counsellors is underplayed and yet they are a vital part of the academic chain in guiding the students. Often students get to see these counsellors for advice during a single period session in Year 13, which is insufficient for both the counsellor and the student to have thorough discussions.

Furthermore, schools, teachers and students have limited option, given the demands of high-stake assessments. Unless the policy makers and education reformers bring in considerable change to allow assessments to be continuous, collaborative and less daunting, the numbers taking science subjects in Year 13 will continue to decline, resulting in the widening inequity for the Māori and Pasifika students in our society. The attitude towards assessments needs to change at a national level. We need to encourage development of skills rather than purely
knowledge. If the system is less assessment driven, teachers will have the freedom to evaluate the educational progress of the students and change their methods of instruction based on students’ needs. Teachers will have the freedom to use more digital technology, hands on experiences, out of school experiences to allow for greater science participation. We will have more participation from Māori and Pasifika students.

6.2 Limitations of the research project

It is imperative to understand that the findings in this case study have come from a group of individuals within a single school. The results provided some clear indications of strong preferences to subject choices based on tertiary studies and career choices by both science and non-science participants. The researcher had doubts if all students (if interviewed) would have had the same level of confidence about their future. There is a possibility that highly confident students had put their names forward for the interview. Undecided students may not have had the inclination for their voices to be heard. Therefore, there may be several gaps in the existing findings.

Though the cohort seemed of a considerable size, it is often difficult to make assumptions, or reflect on the opinions of a large population based on a small representative sample, specifically in matters pertaining to personal decision-making.

While a considerable percentage of the Year 13 cohort (approximately 35%) took part in the online survey, the results would possibly have been more accurate if a higher percentage of the cohort had participated. Given the limitations of time in a busy academic year, only one school was studied.

6.3 Recommendations for further research studies

Students’ voices clearly indicated that there exists a strong correlation between high levels of interest in a subject and the associated experiences provided by various classroom or subject experiences. Much of the literature has also supported this clearly.

Recommendations for further study would include

(i) How teachers can provide engaging experiences within a credit packed curriculum and motivate students to take science at senior levels
(ii) Can science can be integrated with non-science subjects to encourage students to continue with science?
(iii) Are hands on experiences are the answers to motivating students into senior science?
6.4 Concluding statements

While the study was limited to a single low decile South Auckland school involving 104 participants, their personal narratives urge us to re-examine several aspects of our education system. Their voices resonate with the Whakataukī or proverb, below, that has an underlying message to our society with strong implications for the educational fraternity.

Ko te ahurei o te tamaiti arahia o tatou mahi Let the uniqueness of the child guide our work.”
Appendix 1 Student Voice Part A

APPENDIX 1

SURVEY - Part A:

1. Gender: Male        Female        Gender Diverse

2. What is the main language spoken at home other than English?

Arabic, Chinese (Like Cantonese, Mandarin), Fijian, Fijian Hindi, Indian (Like Punjabi, Hindi, Tamil and others), Maori, Samoan, Tongan, Other, English Only

3. Ethnicity (Please Select the one that best applies to you)

Asian, Fijian, Fijian Indian, Indian, Maori, Middle eastern, NZ European, Samoan, Tongan, Other

4. Please select the subjects that you have chosen in Year 13 from the following:

   English

   Languages (Example, French, Hindi, Maori, Japanese, Samoan, Tongan)

   Maths

   Science (Biology, Chemistry, Environmental Science, General Science, Horticulture, Physics)

   Commerce (Accounting, Business Studies, Economics)

   Visual Arts (Digital Art, Art Design, Art photography)

   Music
Technology (Mechanical Engineering, Building construction, Design & Visual Communication, Textile technology)

Hospitality & Early Childhood

Digital Technology & Programming

Drama

Media Studies

Physical Education

Social Sciences (Social Studies, Geography, Classics, History)

Other

1. If you are currently taking Science, please select all that apply to you:

Physics   Chemistry   Biology   Science   Not Taking Science

PLEASE GO TO PART B OF THE SURVEY
**PART B:**

You are asked to read the following statements (25 in total) using the web-based survey. Choose one of the following from the 6 choices given to record your answer. (1) Strongly agree (2) Agree (3) Slightly Agree (4) Slightly Disagree (5) Disagree (6) Strongly Disagree.

**Remember no answers are right or wrong.** Your views are most important to the research study and will be analysed to write the final report.

**PART B - SURVEY**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Agree</th>
<th>Agree</th>
<th>Slightly Agree</th>
<th>Slightly Disagree</th>
<th>Disagree</th>
<th>Strongly Disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning science in years 9 and 10 was very interesting.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I like watching videos or programmes about science on the internet or TV.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Science that I learnt at school can be applied to everyday life</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It was easy to understand science topics in Year 10</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>It is generally fun viewing science content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My peers have influenced my subject choice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>One or more of my family members are studying /have studied science</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>My parents/family members have influenced me with my selection of optional subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Career guidance counsellors have helped me choose my option subjects.

I have selected the subjects based on what I will study at University.

Science classes in Years 9 and 10 had many relevant science experiments.

In years 9 and 10 the science teacher illustrated science concepts using examples from daily life.

Science learning in Year 10 was exciting, because the teacher explained science content using videos and information from the internet.

Participation in science games or competitions increases my interest in learning science.

Group discussions make science classes more interesting.

Science concepts are easy to understand.

Science is one of the best subjects.

I learnt/learn science concepts quickly.
<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>I have got good grades in science</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>Completing classwork in science is /was easy for me.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>Learning science will easily get me a good job</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>Understanding science will benefit me in my career</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Studying science helps to get better paid jobs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>I will be able to use science problem-solving skills in my career</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>My career will involve science/Science, Technology, Engineering, Mathematics (STEM) / Science, Engineering, Medicine (SEM)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Approved by the University of Auckland Human Participants Ethics Committee on (24/05/2018) for 3 years. Reference number (021143)
APPENDIX 2 - Semi-structured interview

Project title: Factors that influence science and non-science option choices in Year 13 at New Zealand secondary schools: Students’ Voices.

Semi-structured interview

Name of student (pseudonym) .................................

M / F / gender diverse

Subjects taken in Year 13: .................................................................

1. Qualitative interview introduction
   Length: 15 minutes
   Primary goal:
   I would like to thank you for your consent to participate in this interview. I wish to inform you that this participation is totally voluntary. The interview is to hear from you the way you see things and your personal opinions. It will be in the form of a conversation with a focus on your experience, your opinions and what you think or feel about the topics covered in our conversation with factors relating to Secondary Science and option choices. It is vital for me to understand student voice. Your voice, as an individual, is important and will provide data for my research. This will be used to analyse the trends among teenagers towards their attitudes in science. Your interests and motivation to select subjects at year 13 and various factors that may influence your decision making is what I am keen to hear. At any point in the interview, if you feel the need to stop the recording you may say so.

2. Background Information
   Overview:

   Invite interviewee to briefly tell me about him/herself.

   After the interviewee openly identifies as having taken Secondary Science subject/subjects or having dropped them they will be asked the following questions.

   1. With regards to science in primary school / intermediate school/ year 9 to 10, can you recall what memories you have of your science lessons?

   2. Can you think of any experiences provided by the science teacher in primary/intermediate/secondary classes that are memorable? (prompt: experiments, activities or filed trips)

   3. To what extent did your experiences of Science in previous years affect your decisions to take science or not to take science in year 13?

   4. What did you like/dislike about the teaching in science classes in years 9 and 10?
1. In your opinion do **topics in science appear easy or very hard for**? Does this impact on subject selection in Year 13?

2. Did **assessments in Science (Eg: Credits)** and **your results from NCEA** influence your decision about your subject choices in Senior classes (Year 12 and Year 13)

3. Which subject areas of Science, **Physics, Chemistry, Biology and Earth Science** have you **liked /did not like** and the reasons why?

4. To what extent are your **parents/family members AND friends involved** in influencing you in making your decisions about your subject choices in Year 13?

5. To what extent are your subject choices made in year 13 influenced by what you will **pursue at University** and why?

6. To what extent **do jobs or careers in the future impact your decisions** on taking the Year 13 subjects?

7. What are your personal views about the **relevance of Science in today’s world**?

8. In your opinion, do you think, **we can do without having to learn Science at all**? Your opinions on this?

9. Given the **technology we have today, to what extent do you think Science influences it all** and why so? Does this impact subject choices in Year 13 in any way?

10. To what extent does the **NZ Science Curriculum motivate or demotivate** students from taking or dropping Science in Year 13?

11. Does learning or **studying science** in your opinion **make a person more prepared for situations in the real world**? Any examples you can think of will be helpful.

12. In your opinion **what changes would you recommend to improve teaching** of science in schools

Approved by the University of Auckland Human Participants Ethics Committee on (approval date to be inserted) for 3 years. Reference number (021143)
Appendix 3 Student Participation Information

STUDENT PARTICIPANT INFORMATION SHEET

Research Title: Factors that influence science and non-science option choices in Year 13 at New Zealand secondary schools: Students' Voices.

Researcher: My name is Su Mukund. I am currently completing my Master of Education degree at the Faculty of Education and Social work at the University of Auckland. I am otherwise a secondary school science teacher.

Project description: The purpose of this study is to understand your opinions on subject selection and option choices at Year 13. Some of you have selected science subjects and some of you have not. My research aims to investigate the possible factors that influence decisions by Year 13 students about your option choices.

Request: You are invited to participate in this study because you are currently in Year 13. Your participation in this research study is completely voluntary. You may choose not to participate. You are assured by the researcher that your participation or non-participation will have no effect on your grades, relationships with teachers, or the researcher. No one at the school will have any way of knowing whether you have taken part in this study or not.

The research project has two phases:

Phase 1 Survey: This phase involves an anonymous online survey with 25 items that will take approximately 10 minutes to complete. The survey can be completely anonymous if you choose. However, at the end of the of the survey you will also be invited to consider taking part in an interview as well. If you are interested, leave an email on the Consent Form. In doing so your survey will no longer be anonymous but will remain confidential.
Phase 2: Interview: This phase involves an interview with the researcher at your school, in a private room where you will be asked questions relating to your experiences in science in years 9 and 10, and the reasons why you may have continued and selected one or more science subjects in Year 13 or why you have decided to drop science subjects totally. This interview will last up to 20 minutes. It will be audio recorded and these recordings will be typed up as transcripts by the University of Auckland approved transcriber who will have signed a confidentiality agreement. You may leave the interview at any time without giving a reason and this will not affect your grades or relationships with teachers or researchers in any way. You will have the opportunity to review the transcripts on request, one week after the receipt of the transcript. Your information will be totally confidential. All data collected will be stored at the University of Auckland for a period of six years after which it will be destroyed. To help protect your confidentiality, the surveys will not contain information that will personally identify you or the school. The results of this study will be included in a Masters’ thesis and will be shared with the school. A link will be provided to the principal once the thesis is uploaded to the University of Auckland library for your perusal. A summary of the research findings will also be available to those who request it. The researcher may be contacted via the email address given below.

If you have any questions about the research study, you can ask me questions directly or contact me, Su Mukund, through the email: smuk015@aucklanduni.ac.nz

This research has been reviewed according to the University of Auckland ethics procedures for research involving human subjects. If you have understood the requirements of this research and would like to participate kindly read the following consent form and give your consent approval.

Contact Details:

Researcher: Sutapa (Su) Mukund  
Email address: smuk015@aucklanduni.ac.nz  
Contact Phone: 0211595429  
Address: 19 Picketling Ave  
Hillsborough  
Auckland

Supervisors:

Dr Gillian Ward  
Associate Head of School (Postgraduate)  
School of Curriculum and Pedagogy  
Faculty of Education and Social Work  
Phone: 623 8899 extn 48840  
E: g.ward@auckland.ac.nz

Dr Aaron Wilson  
Senior Lecturer  
School of Curriculum and Pedagogy
Faculty of Education and Social Work
University of Auckland
Private Bag 92601, Symonds St
Auckland
T: 09 623 8899
M: 027 454 0178
E: aj.wilson@auckland.ac.nz

Approved by the University of Auckland Human Participants Ethics Committee on (24/05/2018) for 3 years. Reference number (021143)
CONSENT FORM (To the Participant)

THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS
Project title: Factors that influence science and non-science option choices in Year 13 at New Zealand secondary schools: Students’ Voices.

Name of Student Researcher(s): Su Mukund
Name of Principal Investigator/Supervisor: Dr Gillian Ward & Dr Aaron Wilson

I have read the Participant Information Sheet, have understood the nature of the research and why I have been invited to participate. I have had the opportunity to ask questions and have had them answered to my satisfaction. I understand that all data will be securely stored at the University of Auckland and will be confidentially destroyed after six years.

- I agree to take part in this research project.
- I agree to complete the questionnaire (approximately 15 minutes) during Form Time.
- I agree to be contacted for an interview if I have left an email at the end of Phase 1 questionnaire.
- I understand that the interview will be approximately 20 minutes long and will be audio recorded. I also understand that the recordings will be typed up as a transcript by an authorized transcriber and that I can request a copy of these to comment on if I wish.
- I understand the voluntary nature of the participation and that I can withdraw at any time without having to give any reason.
- I understand that I may withdraw information that I provide up to three months in this year without having to give any reason.
- I understand that the results of this study will be included in a Masters’ thesis and shared with my school. A link will be provided to the school principal once the thesis is uploaded to the University of Auckland library for any personal interest. A
summary of the research findings will also be available on request from the researcher via the email address below.

- I understand that I will have the opportunity to review the transcripts on request, and edit it if I desire in one week, after the receipt of the transcript.

I agree to take part in this research in (Please circle the choice made by you)

(i) Phase 1: Yes / No. (ii) Phase 2 Yes / No

Approved by the University of Auckland Human Participants Ethics Committee on (24/05/2018) for 3 years. Reference number (021143)
Appendix 5 School Participation Information Sheet

Board of Trustees
(Participant Information Sheet)

Title of the Research Project: Factors that influence science and non-science option choices in Year 13 at New Zealand secondary schools: Students’ Voices.

Supervisors: Dr Gillian Ward and Dr Aaron Wilson
Researcher: Sutapa (Su) Mukund.

Who are we?
My name is Su Mukund. I am a Master of Education student at the Faculty of Education & Social Work at the University of Auckland. My interest in this study is to understand, Year 13 students’ decision making in selecting their option subjects in Year 13. My work is supervised by Dr Gillian Ward and Dr Aaron Wilson from the School of Curriculum and Pedagogy.

Why are you being approached?
The intention of this study is to explore the opinions of Year 13 students about science and the factors that influence their decision making in selecting various subjects at Year 13. As I specifically wish to gather data from a co-educational, state school, with enrolment numbers of 1500+ students and a decile rating of 1-3, you have been approached for this purpose.

What are Year 13 students being asked to do?
Phase 1 Questionnaire: I would like to invite all Year 13 students, from your school to take part in an online questionnaire. The questionnaire uses closed Likert Scale items to obtain data regarding students’ opinion about science. This will mean that students may have to spend up to 15 minutes to complete the questionnaire ideally during a Form
Time. Participation is totally voluntary. After a brief introduction, I will give students a Participation Information Sheet (PIS) and answer any questions they might have. They will then be invited to sign a consent form. The online survey is an anonymous survey. However, if they are willing to participate in phase 2 they will need to leave their email on the consent form. Their information will be kept confidential.

Phase 2 Interview: I would also like to interview 10 of the year 13 students from your school. 5 students would be taking one or more science subjects and 5 students who would not taking any science subjects. Each student will spend about 20 minutes at a time convenient to you and to the students. Students may withdraw from the interview if they choose to do so with no consequences whatsoever to their grades or relationships.

What are you being requested?

I seek permission to visit all year 13 students during form periods most convenient to you and invite them to complete an online questionnaire. Form teachers will be able to leave the room to allow privacy for students. I will supervise the class in the form teacher’s absence. Students who do not wish to participate can remain working on their devices and continue with their personal work.

In addition to the questionnaire I seek permission to recruit and interview up to 10 students to take part in an interview in a private room on the school premises. Since, a total of ten students will be randomly selected via a stratified random sampling method, not all students who may have consented to participate in phase 2 will attend the interview. However, they will be informed about the selection outcome at the earliest convenient time.

Each interview will last for approximately 20 minutes, where the conversation will be audio recorded and recordings transcribed by University of Auckland’s recommended transcriber. Students will have access to these transcripts if they wish to edit them by contacting the researcher. These interviews will take place on the school premises during either a study period or a lunch break on five consecutive days or conditions that best suit your school in a private room that is assigned by you.

Ethical Considerations.

Anonymity and confidentiality: The school will not be identified in the thesis or any other time except by a pseudonym. In Phase 1 most participants will answer an anonymous survey on the web. Only those who wish to take part in Phase 2 will provide an email contact. Confidentiality will be maintained during Phase 2, as interviews will be conducted in a private room at the school and pseudonyms will be used in any subsequent writing or presentations.

Informed consent. Participants’ decision to participate in both Phase 1 and Phase 2 are entirely dependent on their personal consent. They will be provided with a PIS form and consent form that allow them to make this informed decision. Year 13 students are 17/18 years of age and are therefore able to give informed consent as adults.

Participant’s right to withdraw: Participants may withdraw from taking part in the questionnaire or interview at any stage without having to give reason. The interview will
be audio-recorded. Participants may choose to have the audio-tape turned off at any
time during the individual interview. Withdrawal at any stage will not affect their grades,
relationships with teachers or researcher in any way. Participants will have the
opportunity to review the transcripts on request and edit it if desired in a time frame
of one week, after the receipt of the transcript.

The researcher assures that participation or non-participation of students in this
research study will have no effect on the students’ grades, relationships with
teachers, or researcher.

Publications: If information provided is reported or published, it will be done in a way
that does not identify the participants or the school in which the participants attend. A
link will be sent to the Principal once the thesis is updated to the University of Auckland
Library and this can be shared with teachers and all participants.

All information shared with researcher will remain confidential to the researcher, the
researcher’s supervisors and the University of Auckland approved transcriber who will be
required to sign a confidential agreement.

A summary of the research findings will be available to those who request it. The
researcher may be contacted via the email address given below.

Data storage/retention/destruction/future use

All hard data will be stored for 6 years in a locked filing cabinet at the University of
Auckland. Electronic data will be kept on a password protected computer. At the end of 6
years, all files and data will be destroyed.

The data analysis will be used to write my report for Masters’ thesis. If the findings are to
be published, the students’ and school’s confidentiality will be preserved. The Principal
and the Board of Trustees can elect to have a summary of findings emailed to them.

Contact Details:

Researcher: Sutapa (Su) Mukund
Email address: smuk015@aucklanduni.ac.nz
Contact Phone: 0211595429
Address: 4/34 Rosella Road
East Mangere
Auckland

Agreement and Consent:
If you decide to help me organise my research, I would be very grateful. I am happy to
meet with you and answer any further questions that you may have before you sign the
consent form.

Thank you for your time.

Yours sincerely
Su Mukund
Supervisors:

Dr Gillian Ward  
Associate Head of School (Postgraduate)  
School of Curriculum and Pedagogy  
Faculty of Education and Social Work  
Phone: 623 8899 extn 48840  
E: g.ward@auckland.ac.nz

Dr Aaron Wilson  
Senior Lecturer  
School of Curriculum and Pedagogy  
Faculty of Education and Social Work  
University of Auckland  
Private Bag 92601, Symonds St  
Auckland  
T: 09 623 8899  
M: 027 454 0178  
E: aj.wilson@auckland.ac.nz

Approved by the University of Auckland Human Participants Ethics Committee on (24/05/2018) for 3 years. Reference number (021143)
CONSENT FORM (To the Board of Trustees)

THIS FORM WILL BE HELD FOR A PERIOD OF 6 YEARS
Project title: Factors that influence science and non-science option choices in Year 13 at New Zealand secondary schools: Students’ Voices.

Name of Principal Investigator/Supervisor: Dr Gillian Ward & Dr Aaron Wilson
Name of Student Researcher(s): Su Mukund

I have read the Participant Information Sheet and understand the nature of the research and why our school has been invited to participate. I have had the opportunity to ask questions and have had them answered to my satisfaction by the researcher. I understand that all data will be securely stored at the University of Auckland and will be confidentially destroyed after six years.

- I understand that the questionnaire is anonymous for Year 13 students, unless the students are also taking part in Phase 2. In which case, all information regarding the students will be kept confidential by the researcher.
- I understand that students can withdraw from participation at any time without giving any reasons and without any consequences.
- I am aware that participation or non-participation of students in this research study will have no effect on the students’ relationships with teachers, grades or with the researcher as assured by researcher.
- I understand that all data gathered by the researcher towards this research project will remain stored in a secure password protected format at the University of Auckland for 6 years, after which it will be destroyed.
- I understand that the researcher will run the project in 2 phases where students from Year 13 will be invited to participate in a survey followed by 10 students of our school being involved in an interview with the researcher.
- I agree to the researcher having permission to be present in our school for the time-period of her research project in Term 2 of 2018.
I agree to the researcher being present at Form Class to introduce herself and request students to participate in this research programme.
I agree to allow the Form teachers' access to their Form Classes for the research project at a time convenient to them.
I agree to the use of devices for the researcher to gather the data from the participants.
I agree to the school allowing the use of devices/computer labs during this research process where students will answer a web-based questionnaire.
I agree to the researcher conducting the semi-structured interviews in a private room provided by the school.
I understand that de-identified data collected in this research project will be analysed and used for publications publicly accessible media (such as academic journals) and agree to the work being published so long as the school or students are not identifiable in any report.
I understand that the results of this study will be included in a Masters' thesis and will be shared with the school. A link will be provided to the school principal once the thesis is uploaded to the University of Auckland library for any personal interest and perusal. A summary of the research findings will also be available on request. The researcher may be contacted via the email address given below.

I agree to allow our school being involved in the above research project.

Name of the School................................................................

Name of the Principal...........................................

Signature .................................................... Date: ..............................................

Approved by the University of Auckland Human Participants Ethics Committee on (24/05/2018) for 3 years. Reference number (021143)
Appendix 7 Exemplar Coded Student Transcript WS219173

Student B

WS219173 Student B (NAME: Ritika – Female – Science student at Year 13)

I This is student B.

My first question to you with regards to science in primary school, intermediate school and high school what are the memories that come back to you regarding science.

B I feel like in primary and intermediate it was more like not very serious like it is not something that teachers would focus on only with regards to watching videos of the solar and get actually doing experiments so compared to high school it is very like practical based and formulas are getting to know what is actually about whereas in primary and intermediate it wasn’t very extreme to it.

I My second question leads on from the first.

So in terms of experiences that the teachers provided to you in the classrooms what kind of experiences were really motivating or exciting for you.

I I take it you can remember from primary, intermediate and secondary whenever anything that stands out in terms of the science experience that you can think of.

B I think my highlight would be like doing experiments to understand the concept or what we are learning more. So that is generally to go with high school like there is a broad examples of experience which we do so that it is really helpful.

I So again leading on from there to what extent did your experiences of science in previous years affect your decisions to take science in Year 13.

B What do you mean by that.

I So let’s say going back to Year 9, 10, 11, 12 were there any experiences or anything that you had in the class that kind of makes you feel oh I really want to pursue science in my last two years at school.

B Personally I really found science interesting with like the concepts are like the way that it is taught so like it actually changed my mind that I did want to actually do science in Year 12 and 13.

I What do you think about or even dislike about the way science is taught in Years 9 and 10.

B I just think that it is just not as detailed as it should be like teachers don’t go in depth into the concepts and stuff. It is like very broad.

I More general you mean.

B Yeah.

I In your opinion do topics in science appear easy or hard for you.

B It depends on what it is like some topics may be easy for me to understand and some might be really hard.
I So did this impact on your subject selection in Year 12.

B No it didn’t.

I Even if they were hard you were willing to take it.

B Yeah.

I What about science in Year 11? If you don’t, you know, your results in Year 10 did they influence your decision about subject choices in Years 12 and 13.

B They kind of did because it meant that if I didn’t pass then I couldn’t take on the subject that I wanted to do in science. So, like biology, you had to pass Year 11 to even be good for chemistry. So it was quite a struggle to actually pass and get the credits to get into Year 12 and 13 science.

I With subject areas of Physics, Chemistry, Biology and Earth Science which ones would be your favourites and which ones wouldn’t you like that much.

B Biology and Chemistry are my strengths so I enjoy doing those two whereas Physics is very challenging for me, but I did take on Physics in Year 12 and I managed to pass but it was like a struggle but it was something I got there.

I And you dropped it in Year 13.

B Yes.

I To what extent would you say your parents, your family members, and friends would be involved in influencing your decision making for your subject choices in Year 13.

B I think my parents played a huge role in my subjects because in past history, my parents took both science in high school and continued into university so they had the same expectation of me or picking up those subjects and taking it throughout university and doing something as a career in like science.

I Would you say friends have motivated you as well or is it more of your family.

B A lot of motivation because friends, they keep changing their minds so like they say, tell you not to take it but your parents tell you to take it.

I Do you these friends have an influence on students at Year 13.

B Yes they do.

I To what extent are the subject choices made in Year 13 influenced by what you would pursue at university and why.

B Can you repeat that again?

I So, you know, are the subject choices you have taken now are they in anyway connected with what you are going to do at university and is there a link.
B Yeah so I have done biology so that would help me to pursue my career in university by taking on the health sciences in university and that kind.

I And that is exactly what you are looking at at the moment that is your focus.

B Yeah I am very confident that I will do that in university.

I To what extent do jobs or careers in the future impact your decision making about subjects in Year 13? Is there a connection or link at all?

B Yeah so like it is actually believed that things to do with science have higher pay so I think people are influenced by having a higher pay in the future to help them survive the everyday life and stuff.

So I think people do make their decisions by these factors.

I What are your personal views about the relevance of science in today's world?

B I think that science has to do with everything that people generally do like I can't think of an example, but there are like everyday life there is science happening and the way that it is developed into like phones and technology like computers they all have to do with science.

I In your opinion and this is your opinion do you think we can do without having to learn science at all? So students who don't learn science is that okay with them.

B I think it is okay because science is not always the option, you know, you can learn things very similar from other subjects like health and maths like physics and maths connect. So you don't generally like have to take that on in high school.

I Given the technology we have today to what extent do you think science influences it all and why so.

Is there a link between science and technology in your opinion especially with the world around us?

B Yeah because everything happens through technology these days, so like you can pretty much learn anything from online as compared to school and sometimes there is like you can learn more from online. Personally I learned in some subjects online like YouTube where they video themselves teaching subjects have really helped me in passing my exams.

I That is interesting.

To what extent does the New Zealand Science Curriculum motivates students or demotivates students from taking science or dropping science in Year 13.

B I think it demotivates people because it is very challenging and the amount of credits which are given for a student's work is very low. Like in biology you will write 10 pages and the credits are only 3 so it really demotivates people to take science in higher levels because they aren't really afforded what they actually work.
I

Does learning or studying science in your opinion make a person more prepared for situations in the real world?

B

I don't think it prepares people to take on things from the outside world because it is very unexpected.

I

In your opinion what changes would you recommend to improve the teaching of science in schools?

B

I think that teachers should be taught more about going in depth and teaching students how to get an excellence or a merit as compared to focusing on achieving and that makes students think that oh I am only able to get achieve whereas they should be getting higher.

So they don't actually take that much of a time to understand where the students have understood the concept because teachers they move forward with what they plan and some students maybe behind and some students maybe ahead.

So you don't actually know what other students are going through.

I

Thanks a lot.

(End of interview)
## Ten Codes with Illustrative Data Extracts (Direct Quotes)

<table>
<thead>
<tr>
<th>1. Memories of Science in Years 9, 10, 11</th>
<th>2. Range of Internal factors</th>
<th>3. Family and parental influence</th>
<th>4. Influence of friends</th>
<th>5. NCEA credits and University options</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think my highlight would be like doing experiments to understand the concept or what we are learning more (Ritika)</td>
<td>Personally I really found science interesting with like the concepts and like the way that it is taught, so like it actually changed my mind that I did want to actually do science in Year 12 and 13 (Ritika)</td>
<td>I think my parents played a huge role in my subjects because as past history my parents have done science in high school and continued into university so they had the same expectations of me on picking up these subjects and taking it throughout university and doing something as a career in like science (Ritika)</td>
<td>It is more my family because friends they keep changing their minds so like they may tell you not to take it but your parents tell you to take it (Ritika)</td>
<td>Yeah so I have done biology so that would help me to pursue my career in university by taking on like health sciences in university and bio med (Ritika)</td>
</tr>
<tr>
<td>It was all right it was like beer and stuff. I liked all the practical work that we did it was pretty fun that is about it. Yeah we did a few group activities and stuff. I did not like writing (Frederick)</td>
<td>To be honest I really like having practical stuff rather than just the theoretical stuff. So when we have practicals I’m more hands on rather than the theoretical stuff. To be honest last year I liked chemistry better than physics but this year I kind of like physics more because it is more hands on and for physics we more have like practical stuff and more practical stuff than theoretical. So yeah I choose physics. (Apelu)</td>
<td>Yeah my big brother he wanted me to be a builder. Yeah he is a builder as well (Frederick)</td>
<td>Generally not much of my friends actually I do have a lot of friends taking science, but generally I picked statistics because I like doing statistics more than calculus and I can do both, but it wasn’t influenced by any of my friends (Xiaoli)</td>
<td>Pretty much there is a lot of work to it because in university I’m thinking of taking engineering and computational mathematical stuff. So yeah everything helps out with what I’m going to do especially when I’m taking physics and calculus which is mostly needed for engineering and computing science for computational stuff (Apelu)</td>
</tr>
<tr>
<td>Yeah when I was in Year 8 we used to do this game it is to do with physics. So yeah it comes back to me when we are doing sort of stuff like about mechanics and stuff and last year as well we went to Extreme Age and we did the rock climbing. Yeah I still remember that and it was fun and had a lot of experience from it. (Apelu)</td>
<td>I did have science in Year 7 and 8 at my school, but at some point it kind of got lost. Yeah the subject kind of got lost because I don’t remember what we did in science. because science is not really a subject for me (Jafri).</td>
<td>They don’t really know anything about science to be honest. I am like the first one to take science in my family so all they do is tell me that whatever you are good at just keep on doing it and yeah (Apelu)</td>
<td>They always wanted me to be who I want to be so that is why I just go with whatever I want to do, so they always been supportive and stuff. Yeah, my mum studied human biology when she was my age so that actually motivates me so that she can also help me for the stuff I’m stuck on and stuff (Marekerita)</td>
<td>I chose statistics this year because that 15 credits that it gives me a good amount of credits rather than taking calculus which would give me like 7 internal credits (Josefina)</td>
</tr>
<tr>
<td>I remember the experiment with the dry ice and I also remember there was a field trip too, but I don’t know where it was. The thing I like was like we do practical work and we also do like worksheets, but the thing I don’t like is like writing essays (Josefina)</td>
<td>I don’t like physics. For me I just think it is hard and I never learned it (Marekerita)</td>
<td>They always wanted me to be who I want to be so that is why I just go with whatever I want to do, so they always been supportive and stuff. Yeah, my mum studied human biology when she was my age so that actually motivates me so that she can also help me for the stuff I’m stuck on and stuff (Marekerita)</td>
<td>No. Not at all (Marekerita)</td>
<td>It influenced me by passing my stuff so it actually gave me an opportunity to take it this year. Yeah because all I need are 14 credits to go to university that is why I took Bio which is linked to university and biology and maths so yeah. (Marekerita)</td>
</tr>
</tbody>
</table>

Adapted from Braut, Clarke, & Terry (2014)
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Yeah so like it is actually believed that things to do with science have a higher pay so I think people are influenced by having a higher pay in the future to help them survive the everyday life and stuff (Ritika)</td>
<td>Biology and Chemistry are my strengths so I enjoy doing those two whereas Physics is very challenging for me, but I did take on Physics in Year 12 and I did manage to pass, but it was like a struggle but in the end I got there (Ritika)</td>
<td>Everything happens through technology these days, so like you can pretty much learn anything from online as compared to school and sometimes there is like you can learn more from online. Personally, I learned in some subjects online like YouTube where they video themselves teaching subjects have really helped me in passing my exams (Ritika)</td>
<td>Just the way that it feels it is important in some different areas maybe in the world is important. Like all the new phones and stuff. Like cars and stuff that are getting upgraded (Fredrick)</td>
<td>I think it motivates people because it is very challenging and the amount of credits which are given for a student’s work is very low. Like in biology you will write 10 pages and the credits are very less so it really motivates people to take on science in higher levels because they aren’t really afforded what they actually work (Ritika)</td>
</tr>
<tr>
<td>I want to be a carpenter yeah I want to do that sort of thing. And there’s lots of money (Fredrick)</td>
<td>I think yeah science is pretty important and other stuff like physics and stuff but I did not take science (Fredrick)</td>
<td>In my opinion it is more like it depends if it peaks your interest. So I really like science I watch documentaries and many research histories and stuff all by myself just for general knowledge, but sometimes in science are sort of boring in a way when the teacher keeps repeating over and over the same subjects because people have been away and people start going off and stuff and because already heard this multiple times and studying for the exam (Xiaoli)</td>
<td>I think science is the reason why we have like so much advanced technologies with the 3D printing and cell phones that is all created behind science. I think robots, Wi-Fi and computers, Science and Technology is all linked (Josefine)</td>
<td>I’m not sure maybe do a little bit more work a little bit more research on stuff like how it all works and stuff. Rather than writing more hands-on stuff (Fredrick)</td>
</tr>
<tr>
<td>Yes the science I’m doing would take me to do health science and bio medical science next year (Josefine)</td>
<td>To my honest opinion science is pretty much everything we do in life it is all about science, for example what we are doing right now. It is about how we are recording this is science and yeah (Apolo)</td>
<td>I chose geo and stats because it relates to science, the only reason I didn’t took any science subject was difficulty and my teacher told me last year you can do a foundation course as well (Krishna)</td>
<td>Developing science develops our technology development overall is a community, country and people, without science then what is there to research (Xiaoli)</td>
<td>I would like to see them motivate students more so students can have an interest in science subjects because most students I know they are not interested in science (Josefine)</td>
</tr>
<tr>
<td>Taking nursing. Nursing programme. Definitely. Career has influenced decision making - Yes (Marckerita)</td>
<td>Because like if you don’t know like stuff about like hygiene and stuff like that and bacteria it is like really important to society that is why you need to take science I think so (Krishna)</td>
<td>I think there is it is cool like even though I’m not a science student and I don’t take science anymore, but like I see it within my friends, the majority of my friends take bio and physics and chem, I think it still is relevant because it is really cool sitting at lunchtime and hearing them talk about the things that they’ve learned. Like I would be like talking and talking about a tree or something and they would explain what they have learned about that tree or how it is grown (Talia)</td>
<td>I think it kind of makes it easier for societies and other people to find the real world stuff they need to find (Fahida)</td>
<td>For this I would say it is more it is just general it is not extremely motivating, but it is more fun and interesting. It is just like there are some subjects that are more intriguing for students like they have more fun in it (Xiaoli)</td>
</tr>
</tbody>
</table>

Adapted from Braun, Clarke & Terry, G. (2014)
## Appendix 10 Use of Excel For Coding

### Ten Codes with Illustrative Data Extracts (Direct Quotes)

<table>
<thead>
<tr>
<th>Column A</th>
<th>Column B</th>
<th>Column C</th>
<th>Column D</th>
<th>Column E</th>
<th>Column F</th>
<th>Column G</th>
<th>Column H</th>
<th>Column I</th>
<th>Column J</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think my biggest revelation was realizing that science is not just about the numbers and formulas, but also about the stories behind the data.</td>
<td>Personal interest in science and the way it's taught</td>
<td>Family influence on my decision to pursue science</td>
<td>Influence of friends on my decision to pursue science</td>
<td>MCA credits and University options</td>
<td>My career aspirations are heavily influenced by my science background</td>
<td>My attitude towards science is shaped by the way it's taught</td>
<td>Learning science is essential for my future career</td>
<td>My opinion on science and technology is that it's an exciting field that offers endless possibilities</td>
<td>The influence of science on the curriculum is significant</td>
</tr>
</tbody>
</table>

Adapted from Brain, Ellis, & Toms (2013)
References


Brynjolfsson, E., McAfee, A., (2011). *Race against the machine: how the digital revolution is accelerating innovation, driving productivity, and irreversibly transforming employment and the economy.* Digital Frontier Press, Lexington, MA.


