Science and Mathematics Education Centre

Promoting a Career in Engineering: An Investigation of Factors Influencing Career Decision-Making in New Zealand

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DECLARATION

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature:

Date: December 7, 2012

ABSTRACT

This thesis reports on survey research, conducted on a sample of Year 12 students within New Zealand who attended school in the Greater Auckland region during Autumn 2009. The survey gathered data in order to assess the students' knowledge, attitudes, and the perceived influences on those attitudes, towards engineering as a career or field of study. The purpose of the research was to better understand factors that may influence Year 12 New Zealanders' career decisions, especially with respect to careers in engineering, with a view to recommending to stakeholders how enrolment into Bachelor of Engineering programs might be increased.

Schools were selected using stratified random sampling, and their Principals were approached through a strategy of emails, telephone calls, and by local personal contact. The students were surveyed via an online questionnaire, administered by school teachers and/or careers personnel, and conducted within school hours. A total of 292 students from 9 schools within the Greater Auckland region took part, and a variety of statistical techniques was used to analyze their responses.

The New Zealand students were assessed as having a good knowledge of the benefits and demands of a career in engineering, and a positive attitude towards many of the suggested traits of engineering careers. Contradictions were found between the students' perceived influences on their career choices, and the patterns of their response choices to a number of the survey questions. Statistically significant relationships were also found between the gender and ethnic background of the survey sample, the students' attitudes towards careers in general and towards careers specifically in engineering, the influences on those attitudes, and the students' selection of engineering as a career or field of study.

Conclusions were drawn based on the research findings, and recommendations made as to how enrolment into Bachelor of Engineering programs might be increased. The recommendations formulated are directed to practitioners within the engineering

profession and also to advisors within the education sector. Recommendations for additional research are then made.

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GLOSSARY OF TERMS

ABET	Accreditation Board of Engineering Technologists
ASCED	Australian Standard Classifications of Education
ASME	American Society of Mechanical Engineers
AWIS	Association of Women in the Sciences (New Zealand)
MOE	Ministry of Education (New Zealand)
DEEWR	Department of Education, Employment and Workplace Relations (Australia)
DOI	Department of Immigration (New Zealand)
DOL	Department of Labour (New Zealand)
EU	European Union
IEEE	Institute of Electrical and Electronics Engineers (USA)
ICT	Information and Computer Technology
IT	Information Technology
IPENZ	Institution of Professional Engineers New Zealand
LSAY	Longitudinal Study of American Youth
LTSG	Longer Term Strategy Group of Universities (UK)
NAE	National Academy of Engineers (USA)
NAG	National Administrative Guideline (from MOE, New Zealand)
NCES	National Centre for Educational Statistics (USA)
NZSCED	New Zealand Standard Classifications of Education
OECD	Organization for Economic Co-operation and Development
OMRG	Open Mind Research Group (Australia)
Patterns9	Patterns of Higher Education Institutions in the UK: Ninth report
RAE	Royal Academy of Engineering (UK)
ROSE	Relevance of Science in Education
SESTEM	Supporting Equality in Science, Technology and Mathematics
SPSS	Statistical Package for the Social Sciences
STEM	Science, Technology, Engineering and Mathematics
TIMSS	Third International Mathematics and Science Study
UNHDI	United Nations Human Development Index

WES	Women’s Engineering Society (UK)
WIE	Women in Engineering (New Zealand)
WISE	Women into Science and Engineering (UK)

CHAPTER 1

INTRODUCTION TO THE RESEARCH

INTRODUCTION

This thesis reports on research into factors which may affect New Zealand students' career choices, with particular emphasis on enrolment into the field of engineering. The research was stimulated by the consistent under enrolment of New Zealanders into engineering programs, and the under supply of engineers for the New Zealand labour market. Of particular interest was the under-representation of Pākehā[1] and Māori, as students from these ethnic backgrounds form the majority of enrollees into New Zealand undergraduate programs. However, at the time of conducting this research these two groups showed little interest in careers in engineering. Also of interest were the enrolment patterns of the different sexes. In recent times more than 50% of annual tertiary enrolment in New Zealand has been female, yet males have consistently outnumbered females in engineering programs by a ratio of about 4:1.

The literature which supports this work was drawn from a number of science fields in addition to engineering. However, to preserve the focus of this introductory chapter on the New Zealand context, the discussion of the inter-relationships between science and engineering, and hence the relevance of the information from those fields to this work, is delayed until the beginning of the following chapter.

Ten years ago, the author summarized the situation regarding the declining enrolment into engineering programs and the under-supply of engineers both within the context of New Zealand and within the context of selected Western industrialized nations (Craig, 2002). At that time of writing, the industrialized nations of the world

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[1] Pākehā is the term used to describe a person who is a New Zealander, non-Māori, of European Caucasian extraction (Ryan, 1995).

were described by Kelly (2001), Baillie and Fitzgerald (2000), and by Rubin, Angelo, Powers, Rosenbaum, and Reina (2000), as experiencing difficulties attracting and retaining engineering students. A decade of declining enrolment in the US was reported by Kelly (2001) who revealed that student numbers in engineering programs had reduced by around 13%. It was also reported that fewer students were pursuing mathematics and science in their senior school years, and fewer females were choosing careers in engineering than were their male counterparts. The New Zealand context in 2002 was not quite the same. Data from The Ministry of Education (MOE) Web site report, *Profiles & Trends 2000*, indicated that both male and female senior school students could be seen as having persisted at mathematics and science, with males showing a greater interest in physics and females a greater interest in biology (Craig, 2002, p. 72). However, similar to reports from Western industrialized nations, *Profiles & Trends 2000* indicated enrolment into engineering degrees as a percentage of total first year degree program enrolment was low, even though the New Zealand Department of Immigration (DOI, 2001) showed an under supply of engineers on their skills shortage lists for every major New Zealand city. Male enrolment into engineering programs in New Zealand outweighed female enrolment by a ratio of approximately 4:1, and the enrolment figures of different ethnic groups indicated Pākehā and Māori, who at that time formed about 82% of the annual enrolment, appeared to show less interest in engineering than did those from Chinese, Indian and other Asian backgrounds. *Profiles & Trends 2000* also indicated that New Zealand "had a lower proportion of graduates than the OECD average in higher-level awards in engineering, manufacturing, and construction; and in the mathematics and computer science category" (Profiles & Trends 2000, p. 28).

Since the publication of *Profiles & Trends 2000* there has been a number of affirmative action initiatives aimed at increasing enrolment, especially among females, into engineering and technology programs. In the UK, the US, and Australia, new associations or female chapters of existing associations were opened, the central objective of which was to attract and retain females into the fields of science and engineering. In New Zealand professional bodies have been working with schools to promote science, and a directive from the New Zealand MOE, NAG/1/f[2], requires that schools "provide appropriate career education and guidance for all students in year 7 and above" (Rethinking Career Education in Schools, p. 9).

Affirmative action initiatives will be discussed in greater detail later in this thesis, however, the situation in New Zealand which stimulated this research in 2008, was the continued and consistent under enrolment of New Zealanders into engineering programs and the persistent under supply of engineers to the New Zealand labour market; the same situation that motivated the author's publication on this topic in 2002. Furthermore, the students' enrolment statistics available from 2009, which will also be discussed later in this work, showed in a manner very similar to that reported in 2002, that New Zealand school students persisted at mathematics and science; enrolment into engineering degrees as a percentage of total enrolment was low; the ratio of males to females enrolling into engineering programs was approximately 4:1; and that of the ethnic groups investigated, Pākehā and Māori, who when combined still formed about 80% of the annual enrolment, again showed little interest in engineering when compared with their Asian contemporaries.

The growth of a nation depends on innovation, and the ability to realize those innovations depends on a steady supply of scientists and engineers (Campbell, 1999). The New Zealand immigration strategy reflects the needs of the nation, and in 2007 the DOI featured engineers and technologists on its skills shortage list for every major geographical region of New Zealand[3]. This was not a new situation as the shortage of engineers had appeared on these same ministry lists since the year 2000, and had also been reported by the Institution of Professional Engineers New Zealand (IPENZ) in 2001. A decade later, an introductory paragraph to the *Opportunities* section of the New Zealand DOI Web site stated that "many industries within New Zealand say that one of the most significant factors holding them back

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[2] Ministry of Education National Administration Guideline, section 1, sub-section f. Retrieved from http://www.minedu.govt.nz/theMinistry/EducationInNewZealand/EducationLegislation/TheNationalAdministrationGuidelinesNAGs.aspx

[3] Retrieved from http://www.immigration.govt.nz/migrant/general/generalinformation/media/lists.htm

from achieving growth is the lack of qualified staff'[4]. For New Zealand to continue to develop as an industrialized nation, a steady stream of good quality New Zealand students needs to be attracted into a range of engineering programs.

Engineering Professionals: Supply Versus Demand

Despite drives internationally to increase the number of students enrolling into engineering and technology programs, no sustained improvement had been seen by the end of 2010. In the UK, there were the promotional activities of societies such as EngineeringUK[5], whose aim was to improve the perception of engineering among the youth and their influencers. In Australia, the state government of Victoria launched a careers awareness campaign entitled *ICT: Start Here. Go Anywhere*[6], and in New Zealand, IPENZ had initiated *Futureintech*[7]: working with schools in order to promote the students' interest in science. Contrary to the aims of these institutions and associations, enrolment into first year engineering and technology degrees in the UK declined significantly in absolute numbers between the years 1995 and 2003, and as a percentage of total enrolment between 1995 and 2008. In Australia, ICT enrolment decreased by 38% between the years 2002 to 2008, and in New Zealand, although greater numbers of students were attracted for a few years after the turn of the century, from 2003 until 2009 those enrolment numbers steadily fell.

Increasing the enrolment of females in particular, into science, engineering, and ICT programs, was the specific objective of a range of affirmative action strategies. In the UK, associations such as Women into Science and Engineering (WISE)[8] and the

[4] Retrieved from http://www.immigration.govt.nz/migrant/stream/work/ skilledmigrant/Link Administration/ToolboxLinks/essentialskills.htm?level=

[5] Retrieved from http://www.engineeringuk.com/what_we_do/research/research_and_briefing _papers.cfm

[6] Retrieved from http://australia.gov.au/topics/employment-and-workplace/australian-government-jobs/ict-entry-level-programs

[7] Retrieved from http://www.futureintech.org.nz/

[8] http://www.wisecampaign.org.uk/

Women's Engineering Society (WES)[9] arose, and in the US, the National Academy of Engineering (NAE) launched a Web site named *Engineer Girl!*[10]. A number of female-oriented journals were also created including an equal opportunities publication *Women in Engineering*[11], and also *IEEE Women in Engineering*[12] whose mission in 2011 included the words "to inspire, engage, encourage, and empower IEEE women worldwide". In Australia, the *Women in Engineering* branch of *Engineers Australia*[13] indicated its aim was to create an inclusive engineering society, and in New Zealand, there were the activities of the *Association of Women in the Sciences* (AWIS)[14] and *Women in Engineering* (WIE), a student-run society associated with the University of Canterbury[15]. However, contrary to the aspirations of these activities, the under-representation of female enrolment into engineering and/or computing degree programs continued to be an international phenomenon.

From the time of the author's paper on the topic of declining enrolment into engineering degrees (Craig, 2002) until commencing this thesis, the requirement for graduate engineers had not diminished. Craig (2002) originally commented that Bellinger (1997) and Kubel (2001) reported the demand for graduate engineers in the US was high, Marcus (2001) reported salaries for qualified engineers were also high, and Coy and Whalen (2001) indicated that in order to maintain long-term growth there was a strong demand to fill positions across a range of engineering fields. A decade later in Australia, the Victorian state government sponsored research into the attitudes and knowledge of school students because of a perceived declining interest towards ICT, and in New Zealand in 2012, engineering and ICT again appeared on the skills shortages lists of the DOI Web site. The DOI however, also created a new list named the *Long Term Skill Shortage List* (LTSSL). The LTSSL was pertinent to

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[9] http://www.wes.org.uk/

[10] http://www.engineergirl.org

[11] http://www.eop.com/mags-WE-subscription.php

[12] Retrieved from http://www.ieee.org/membership_services/membership/women/index.html?WT.mc_id=WIE_nav1

[13] Retrieved from http://www.engineersaustralia.org.au/groups/women-in-engineering/women-in-engineering_home.cfm

[14] http://www.awis.org.nz

[15] www.icts.canterbury.ac.nz/news/uclive.shtml

this work because engineering featured in the list, the purpose of which was to identify “those occupations where there is an absolute (sustained and ongoing) shortage of highly skilled workers both globally and throughout New Zealand”[16].

ENROLMENT INTO, AND STUDENT PREPARATION FOR, ENGINEERING PROGRAMS IN NEW ZEALAND

The following section outlines the tertiary enrolment patterns into engineering and competing programs in New Zealand across the years 2003 to 2009, as well as enrolment for the year 2009 based on ethnic background and gender difference. Enrolment of New Zealand senior school students at science and other selected subjects is also considered, as such enrolment is an indicator of the students' preparation for the academic challenges of professional engineering programs.

Tertiary Enrolment within the New Zealand Context

Examination of New Zealand government reports related to the tertiary education sector, made available on the MOE Web site *Education Counts*[17], revealed similarities between student enrolment patterns in New Zealand and those of other industrialized nations. The series of MOE annual reports entitled *Profile & Trends,* and the Ministry data on domestic enrolment into tertiary education programs, showed that New Zealand was likewise struggling to attract students into the fields of engineering and the more mathematical sciences. Though some brief improvement was occasionally detected, enrolment into engineering and IT programs showed general decline from 2003 until 2009. The enrolment data for a selection of bachelor degree programs within the New Zealand tertiary sector have been extracted from the MOE reports and reproduced in Table 1.1.

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[16] Retrieved from http://www.immigration.govt.nz/migrant/stream/work/ skilledmigrant/Link Administration/ToolboxLinks/essentialskills.htm?level=1 (DOI, Essential skills in demand, accessed May 2012)

[17] Retrieved from http://www.educationcounts.govt.nz/statistics/schooling/ july_school_roll_returns/6028

Table 1.1: Ministry of Education Domestic Tertiary Enrolment 2003-2009

Year		Engineering and IT	Society and Culture	Creative Arts	Natural Sciences	Health fields	Management & Commerce	Other Programs
2003	Student enrolment	7,330	28,770	8,560	10,530	10,770	12,160	11,000
	% of total enrolment of 89,120 students	8.0%	32.0%	9.6%	11.8%	12.1%	13.6%	12.3%
2005	Student enrolment	5.960	27,840	8,940	10,890	11,540	12,190	10,470
	% of total enrolment of 87,830 students	6.8%	31.7%	10.2%	12.4%	13.1%	13.9%	11.9%
2007	Student enrolment	5,490	28,480	9,780	11,410	13,360	12,400	10,200
	% of total enrolment of 91,120 students	6.0%	31.0%	10.7%	12.5%	14.7%	13.6%	11.2%
2009	Student enrolment	6,070	30,460	9,570	11,900	13,090	15,780	11,850
	% of total enrolment of 98,720 students	6.1%	30.9%	9.7%	12.1%	13.3%	16.0%	12.0%

Note.
Data source: New Zealand Ministry of Education Tertiary Enrolment Statistics http://www.educationcounts.govt.nz/statistics/tertiary_education/participation, Provider-based Equivalent Full-time Students: Field of Study, [Index- bach trnds].[18]

The data shown in Table 1.1 indicate that although an improvement in enrolment into engineering and IT programs could be seen from 2007 to 2009, the student numbers in both in absolute and percentage terms were below those for 2003. From 2003 to 2009, enrolment dropped by around 1,250 students in terms of absolute numbers, and by nearly 2% as a percentage of total enrolment: a loss of over 20% of the intake when considering just the intake for engineering and IT. Over the same period, the percentages in the fields of society and culture, the creative arts, the natural sciences, and health remained relatively stable. The field of management and commerce however, attracted increasing numbers of students during the years 2003 to 2009, up by some 3,500 students or about 2% of total enrolment.

Data relating to enrolment into bachelor degree programs by ethnicity were also available on the New Zealand MOE Web site. Table 1.2 shows enrolment figures into selected degree programs, based on ethnicity, as a percentage of the total tertiary enrolment during 2009.

[18] *Index-bach trnds* indicates that to reach the referenced data for this table it is necessary to go to the page pointed to by the url, choose the spreadsheet as named, and then click on the index link labeled *bach trnds.*

Table 1.2: Enrolment into Tertiary Fields of Study by Ethnicity as a Percentage of Total Enrolment in 2009

Ethnicity Field of Study	Pākehā %	Māori %	Asian %	Other groups %	Totals %
Humanities	22.3	4.2	4.5	3.6	34.6
Education	6.2	1.5	0.7	0.1	8.5
Commerce	10.0	1.4	4.0	2.1	17.5
Health	9.0	1.5	2.6	1.6	14.7
Engineering and IT	3.8	0.5	1.7	0.8	6.8
Other fields	17.7	1.9	4.5	3.8	27.9
Totals	69%	11%	18%	12%	110%

Notes.

1. Data source: http://www.educationcounts.govt.nz/statistics/tertiary_education/partici-pation, Provider-based Equivalent Full-time Students: Field of Study (Index-bach eg)
2. Students may enroll in more than one field and will be counted in each field. hence the enrolment total exceeds 100%.

It can be seen from Table 1.2 that in 2009 Pākehā formed approximately 69% of the tertiary enrolment, yet engineering and IT appeared to be significantly less popular to them than did programs in other fields. Proportionately only 5.5% (3.8% of 69%) of Pākehā chose to study IT and engineering. Māori students showed even less interest with just 4.5% (0.5% of 11%) choosing engineering and IT, and similarly to Pākehā, engineering and IT were their least preferred programs of study. Asians however, with 9.4% of their total enrolment (1.7% of 18%), appeared to show approximately twice as much interest in engineering and IT than did their Pākehā and/or Māori counterparts.

School Student Preparation for Engineering and Related Programs within the New Zealand Context

The New Zealand situation relating to the persistence with science subjects by senior school students was not the same as the situation in the US, as reported at the turn of the century by Kelly (2001), Baillie and Fitzgerald (2000), and Rubin et al. (2000), and a decade later reported, again from the US, through the Web site of the National Center for Educational Statistics (NCES, 2011). Statistics from the New Zealand MOE Web site, *Education Counts*, showed that the enrolment of New Zealand students into school science subjects ran contrary to the reported subject selection of students from the US and the UK. Table 1.3 is a selection of the data available from *Education Counts*, relating to school subjects into which final year students were enrolled in New Zealand.

Table 1.3: Enrolment into Selected School Subjects by Final Year School Students in New Zealand: 2001, 2007 and 2010

Subject	Year	M	F	Total	Subject	Year	M	F	Total
Accounting	2001	2,121	2,227	4,348	English	2001	8,461	11,320	19,781
	2007	1,873	1,659	3,532		2007	9,336	13,216	22,552
	2010	1,803	1,587	3,390		2010	11,987	16,028	28,015
Biology	2001	3,421	5,406	8,827	Physical Education	2001	3,858	2,900	6,758
	2007	3,135	5,771	8,906		2007	4,628	3,692	8,320
	2010	3,748	6,837	10,585		2010	5,320	3,775	9,095
Chemistry	2001	3,575	3,320	6,895	Physics	2001	5,329	2,718	8,047
	2007	3,422	3,978	7,400		2007	4,756	2,671	7,427
	2010	4,208	4,751	8,959		2010	5,645	2,998	8,643
Computer studies	2001	2,253	1,784	4,037	All Maths	2001	13,950	10,985	24,935
	2007	2,868	2,464	5,332		2007	14,070	12,227	26,297
	2010	3,138	2,671	5,809		2010	16,876	14,616	31,492

Note.
Data source: New Zealand Ministry of Education Tertiary Enrolment Statistics. www.educationcounts.govt.nz/statistics/schooling/july_school_roll_returns/6052

The data of Table 1.3 suggest that school students in New Zealand were not deserting the field of science for other fields, and nor was there a considerable change in enrolment from the more mathematical subjects such as physics, to those of biology and chemistry. The data in Table 1.3 show an increase in enrolment into physics as well as chemistry and biology courses during the selected years of 2001, 2007 and 2010, and also indicate a consistent uptake of mathematics subjects by senior school students, with a reasonable balance of male and female enrolment. There was however an imbalance of enrolment into senior school physics, with males outnumbering females by a ratio of almost 2:1.

In addition to the school subjects shown in Table 1.3, there is a range of other subjects which are reported through *Education Counts* under the collective title of *Technology*. Table 1.4 shows the list of technology subjects, and the male and female enrolment of Year 13 students into those subjects during 2007.

Table 1.4: Enrolment into Technology Subjects by Final Year School Students in New Zealand in 2007

Technology Subject	Male	Female	Total
Computer science/programming	197	111	308
Computer studies	2,868	2,464	5,332
Design, Drawing and Graphics	530	264	794
Electronics and Control	162	6	168
Food Technology	547	1,171	1,718
Graphics	1,279	763	2,042
Info. & Communication Tech	855	906	1,761
Materials Technology	584	297	881
Structures and Mechanisms	50	1	51
Technology	742	418	1,160
Text & Information Management	437	813	1,250
Textiles/Clothing	37	812	849
Total	8,288	8,026	16,314

Note.
Data Source: http://www.educationcounts.govt.nz/__data/assets/excel_doc/0020/34607/Ed_Stats_formats_applied_for_printing_final.xls

The content of Table 1.4 shows not only the student enrolment figures but also the names of the school subjects which are grouped under the term technology. The enrolment figures indicate that with the exception of food technology, information and communication technology, text and information management, and textiles and clothing, males enrolled in greater numbers than did females into school technology. However, the total enrolment into technology subjects by the different sexes was similar. Table 1.4 also shows that the names of the school subjects do not align with programs offered by many academic institutions, as previously described as tertiary enrolment figures for Table 1.1. For example, subjects such as design, drawing and graphics, and textiles and clothing, which within the schools framework are termed *technology*, relate to *creative arts* within the tertiary framework[19].

Data from the MOE Web site, *Education Counts* also showed that in the year of conducting the survey for this work, 2009, far more females (18,330 students) than males (12,010 students) enrolled in bachelor degree programs.

In summary, the data recorded in Table 1.1 to Table 1.4 illustrate that the continued enrolment by New Zealand students in mathematics, science and technology subjects at the school level, did not translate into high enrolment into engineering as a field of study at the undergraduate level. Only a small minority, about 6%, of the New Zealand school leavers chose to study degrees in engineering or related fields, a phenomenon which was similar to that of their Australian, US and UK counterparts, as shall be discussed in greater detail in the following chapter. Neither was the similarity between male and female enrolment in school science subjects reflected by a similar number of enrollees of each into engineering programs. Despite female dominance of enrolment into bachelor degrees in 2009, and despite female persistence with science courses in senior school, far fewer females than males selected engineering as a career or field of study.

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[19] The imprecise nature of the term *technology* is further discussed in Chapter 2, in relation to the relevance to this work of data from a variety of fields, and discussed again in Chapter 5, in relation to the interpretation of some of the survey results.

OVERVIEW OF THE RESEARCH

The Research Problem

The intent of this research is to increase understanding of why only a small minority of school leavers in New Zealand were motivated to choose engineering as a career or field of study. There appeared to be an anomalous situation whereby student enrolment at school science courses in New Zealand was different from that of the US, Australia, and the UK, and yet the declining interest in enrolment into undergraduate engineering programs by both males and females in New Zealand was similar to that of the US, Australia, and the UK.

Did the attitudes of New Zealand students mirror those of Australian youth from the state of Victoria who were surveyed in 2009? Did they feel they had insufficient knowledge of the tertiary programs and ICT career opportunities, or were they put off ICT by the perceived lack of human interaction? If so, who or what had shaped their perceptions? Of interest in particular would be the responses of Pākehā and Māori, because these groups show disproportionately low levels of enrolment into engineering programs as compared to their contemporaries from other ethnic backgrounds. Likewise the responses of the female students are of particular interest, as their enrolment into engineering programs is similarly disproportionately low when compared to male enrolment.

The specific questions which this research was designed to address were aimed at understanding the knowledge, attitudes, and perceived influences on those attitudes, of New Zealand school students when related to engineering as a career or field of study. The pursuit of such a study on a national scale was considered unfeasible however, and so a smaller geographical area was chosen. The Greater Auckland[20] region was chosen for reasons of relevance and convenience. Greater Auckland

[20] The Greater Auckland region consists of: Auckland City, Franklin District, North Shore City, Manukau City, Papakura District, Rodney District, and Waitakere City.

contained approximately 35% of the New Zealand senior school students, and so was considered likely to give some indication of the responses which might have been returned from the senior school population as a whole; and in terms of convenience, the author's New Zealand home is within the Greater Auckland region. Hence the research questions to be addressed became:

1. What do Greater Auckland students know of careers in engineering?
2. What are the attitudes of Greater Auckland students towards engineering as a career or field of study?
3. What factors do Greater Auckland students perceive have influenced their attitudes towards engineering as a career or field of study?
4. What recommendations can be made to assist school career advisors in guiding students in their consideration of engineering as a career?

Overview of the Research Design

In order to reveal what all Greater Auckland senior school students felt about engineering as a career or field of study, and why they might have felt that way, would have required gathering data from all senior school students in Greater Auckland. Collecting the data of a population of over 20,000 school students from the whole of the Greater Auckland region would have required huge resources, the cooperation of every school in the region with a senior student department, and also the cooperation of all the students themselves: an unrealistic expectation. Hence a method of collecting data from a representative sample, within acceptable limits of accuracy, was required. The random sampling of a population is a proven method of creating a sample of a population which, within statistical limits based on the sample size, reflects the characteristics of the population as a whole (Bouma, 1996).

According to Page and Meyer (2000), a self-administered questionnaire can be designed to gather valid data which reflects personal opinion, and given that this research seeks understanding regarding the students' knowledge and attitudes, it is appropriate to use such a style of questionnaire in order to gather data from the

Greater Auckland students. Consequently, distributing a self-administered questionnaire to an appropriately selected sample of senior school students was considered a valid approach to gathering data. It was also considered that the results of the analysis of their responses could be inferred, within a predetermined level of confidence, to be a reflection of the likely responses of the Greater Auckland student population.

The questionnaire was designed so that the items were clustered by topic around the research questions. In turn the research question content was stimulated by the findings of the literature reviewed, and reported in this and the following chapter. Research from Australia, the UK, and the US indicated that the student populations surveyed in those countries seemed uninformed about ICT and engineering; some students felt they were poorly prepared at school, and that their career choices were subjected to a range of influences including family, friends, and the media. Consequently the questionnaire was designed to gather data related to the New Zealand senior school students' knowledge about careers in engineering, the possible sources of that knowledge, and the perceived influences of the various sources. In addition there were demographic questions so that internal influences on attitudes towards engineers and/or career choices might be detected.

The questionnaire was peer-reviewed by a group which included those with industrial and/or academic experience; critiqued by a group of school students of similar ages to those of New Zealand school leavers; field tested online; and administered to the sample in their schools by their own school staff.

The Significance of this Research

This study is significant because of the persistent under supply of engineers within New Zealand and, as previously noted from the *Opportunities* section of the New Zealand DOI Web site, the negative effect this has on the development of the industrial sector. The research is designed so as to produce results which will give insight into the influences on career choice of youth within the Greater Auckland region; bringing focus to the low enrolment into engineering programs by New Zealand students despite their persistence at school science subjects. Many New Zealand school leavers had the opportunity to enroll into engineering programs, but like school leavers in the US, the UK, and Australia, only a small minority chose to do so.

It is anticipated that the insights resulting from this research will inform school career advisors, professional engineering bodies, and tertiary institutions, as well as indicating the direction for further research. It is important that the stakeholder institutions are alert to the positive aspects of engineering which need to be promoted, and the negative aspects which need to be addressed. Careers advisors likewise need to be aware of the students' knowledge about engineering, and the likely influences on their attitudes towards careers in engineering, as they attempt to match the expectations of school leavers with the realities of life as an engineer.

The potential effect of ensuring students have positive attitudes regarding careers in engineering is shown by the following analysis. From the turn of the century until the time of writing, Pākehā and Māori have collectively formed around 80% of the tertiary enrolment in New Zealand, yet persistently during that time only approximately 5% of them chose to enroll into engineering programs. Compounding the low enrolment into engineering programs is the low uptake by females. Increasing enrolment into engineering by Pākehā and Māori to proportions similar to those of Asian and Indian students, and increasing the enrolment of females to the enrolment proportions of males, would generate approximately 7,000 additional engineering enrollees per annum. Such an increase in enrollment, and the subsequent increase in graduate engineers, would potentially contribute to the alleviation of the shortage of professional engineers in New Zealand, and to sustained industrial development.

Overview of the Thesis

In this chapter, the research problem and its background were described, the research questions developed, and an overview of the research provided. The emphasis of this chapter has been towards the New Zealand context.

The following chapter expands the context to review academic papers, reports commissioned by government, and reports published on government Web sites, from a number of industrially developed nations, including the US, Australia, and the UK. The topics covered are related to the close inter-relationship of many of the science fields; the preparation of school students for enrolment into tertiary science programs; their choices of programs of study; the possible influences on their enrolment; and their attitudes towards careers in general as well as possible influences on attitudes towards careers in engineering.

Chapter 3 presents the argument for the research design adopted. The survey approach and the sample selection method and quantities are explained, as are the design and creation of the questionnaire. The questionnaire review and adjustment process is described, as is the strategy used to engage with the survey sample, and also the administration of the questionnaire. Finally for Chapter 3, ethical issues are discussed and the appropriate approval noted.

Chapter 4 reports on the responses gathered through the questionnaire and the findings from the subsequent statistical analyses of those responses.

Chapter 5 positions the results of this research with respect to the present body of knowledge, and recommends how engineering and related programs might be promoted to school students. Chapter 5 then concludes with recommended directions for further research.

CHAPTER 2

LITERATURE REVIEW

INTRODUCTION

In order to further contextualize the research problem addressed in this thesis, this chapter builds on the background literature related to the research which was introduced in Chapter 1. In this chapter, the discussions on student enrolment patterns into tertiary programs and student preparation for tertiary studies, are expanded to include information from research relating to selected Western industrialized nations. Following the discussion of the student enrolment and preparation while at school, is a review of attitudes towards science and engineering, and suggested influences on students' career choices. The topic of women in engineering and science is addressed, as are the affirmative action activities which were designed to attract and retain women into science programs, and in particular into engineering careers.

The majority of the literature reviewed was related to the US, the UK, Australia, and New Zealand, with additional references from reports related to pan-European data. The literature is summarized with a focus on the areas to be examined through this research.

As indicated in the introduction to this research however, prior to these discussions on student preparation, enrolment, and attitudes, it is necessary to clarify the inter-relationship between a range of scientific fields, and to show how information gathered from each of them was relevant to this research which focused on engineering.

Overlapping Terms and Fields: Engineering, Computer Science, Technology, Information Technology (IT), and Information and Computer Technology (ICT)

Academic papers and government reports have addressed over the years a variety of topics within and across the numerous science fields. These papers and reports have been based on information which sometimes treated the fields separately, and on other occasions the data from these fields were reported collectively. The terms engineering, computer science, technology, IT, and ICT are not synonymous, although the relationships between them are frequently acknowledged. For example, the Web site of the University of Cambridge[21], UK, expressed in its undergraduate enrolment section on the pages devoted to computer science that, "Computer science is a fast-moving field that brings together many disciplines, including mathematics, programming, engineering, [and] the natural sciences" (University of Cambridge, accessed 2012); and in the US, the Engineers' Council for Professional Development (renamed in 1980 as The Accreditation Board for Engineering and Technology [ABET]), defined engineering as the "creative application of scientific principles to design or develop structures, machines, apparatus, or manufacturing processes"[22]. These were just two examples where computer science was acknowledged as including the field of engineering, and engineering was acknowledged as including the field of science.

Information technology (IT) evolved from the field of engineering and was defined on Princeton's *wordnet* as "the branch of engineering that deals with the use of computers and telecommunications"[23]. Information and computer technology (ICT) could be seen as a reference to vocational level IT courses and/or a generic term for the computer industry. For example, the Australian federal government Web site contains information on their *ICT Apprenticeship Program*[24] and *ICT Cadetship*

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[21] Retrieved from http://www.study.cam.ac.uk/undergraduate/courses/compsci/

[22] Retrieved from http://www.abet.org/History

[23] Retrieved from Wordnetweb.princeton.edu/perl/webwn?s, [search IT]

[24] http://australia.gov.au/topics/employment-and-workplace/australian-government-jobs/ict-entry-level-programs

Program, whereas Bond University indicated their School of Information Technology (SIT) has a strong relationship "with the ICT Industry and its complimentary [sic] partners"[25].

The inter-relationship of these fields and programs of study was further tightened by the standard classifications of education for both Australia (ASCED[26], 2001) and New Zealand (NZSCED[27]). Both sets of academic standard classifications subsumed the field of computer science into the broader education field of IT.

The close inter-relationship between the fields of computer science, engineering, IT and ICT, naturally resulted in similarities between some topics within the academic programs and similarities in the requirements for program enrolment. The similarity of knowledge within programs could be seen from the New Zealand Standard Classification of Education (NZSCED), which indicated within its sections on Narrow Fields of Education that variations on topics such as mathematics, data structures, and programming were taught in each of computer science, IT, and engineering programs. The similarity of entry criteria could be seen from reviewing university Web sites, for example from the University of Queensland[28], Australia, the University of Auckland[29], New Zealand, and the University of Cambridge, UK. The entry criteria posted on their Web sites indicated that their computer science programs required a strong mathematics background, and for entry into Bachelor of Engineering programs there was also an expectation of good grades in physics and/or the physical sciences.

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[25] Retrieved from http://www.bond.edu.au/degrees-and-courses/undergraduate-degrees/list/bachelor-of-information-technology/index.htm

[26] Retrieved from http://www.abs.gov.au/ausstats/abs@.nsf/0/8D78ACD7005DDD62CA256AAF001FCA6E?opendocument

[27] Retrieved from http://www.educationcounts.govt.nz/data-services/collecting-information/code_sets/new_zealand_standard_classification_of_education_nzsced/nzsced_broad_fields_of_study

[28] Retrieved from http://www.uq.edu.au/study/program.html?acad_prog=2001

[29] Retrieved from http://www.engineering.auckland.ac.nz/uoa/

Thus, this research drew on literature from each of the fields of science, technology, IT, ICT, and engineering. Their close inter-relationship has meant that information from the different fields has on occasion grouped together in reports, and also that information which emerged from one field was likely to have implications for one or all of the other fields. For example Figure 2.1, to be discussed later in this chapter, shows data from the UK relating to *Engineering and Technology*, and papers by Bellinger (1997) and Rubin et al. (2000), which are also discussed later in this chapter, quite simply refer to school student preparation in the US for *science degrees*.

This chapter now continues with a review of selected literature from a range of fields of science. The issue of declining enrolment into Bachelor of Engineering programs, and the enrolment of students at school science subjects, was discussed in Chapter 1 with the focus predominantly on the New Zealand context. The following section of this thesis now broadens the context of the literature, reviewing information related to other industrialized nations, including the UK, the US, and Australia. The focus is on enrolment into engineering and related programs, and also on factors concluded from prior research as possibly affecting that enrolment.

ENROLMENT INTO BACHELOR OF ENGINEERING DEGREE PROGRAMS WITHIN THE CONTEXT OF SELECTED WESTERN INDUSTRIALIZED NATIONS

Tertiary Enrolment Patterns within the UK Context

First year student enrolment into undergraduate engineering and technology degrees for 1995 to 2003 in the UK is the subject of a report from the UK Resource Centre for Women (2010), the data from which are represented in Figure 2.1.

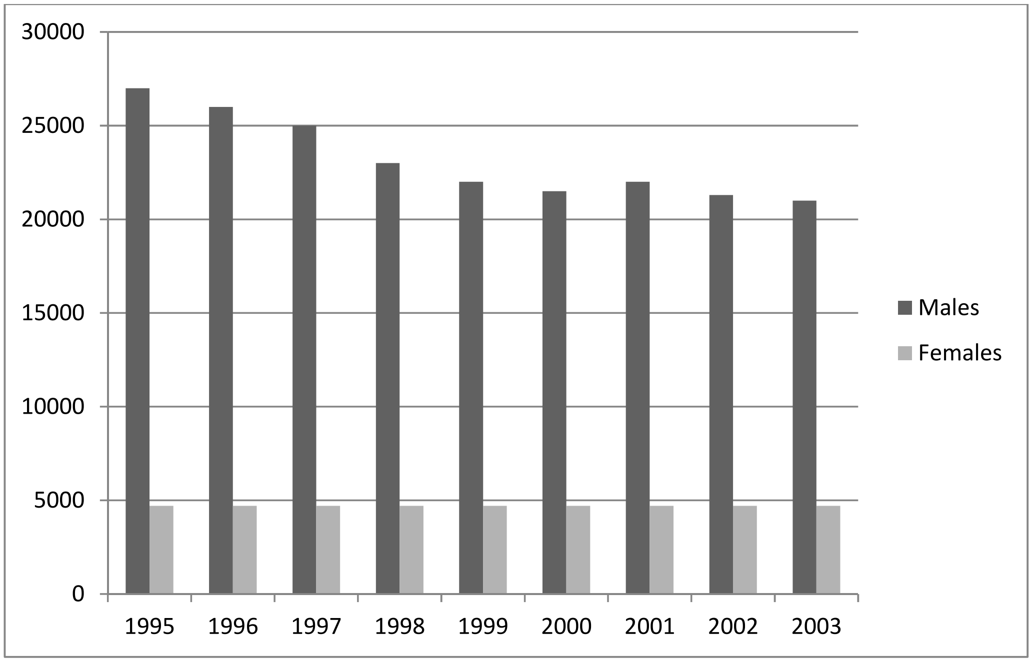


Figure 2.1: First year full-time first degree undergraduates in engineering and technology.

Source: UK Resource Centre for Women (redrawn by author).

The graph of Figure 2.1 shows a profile with an almost continuous reduction of total first year enrolment during the nine years depicted. The combined male and female enrolment into engineering and technology dropped from approximately 30,000 students in 1995 to around 25,000 students in 2003, with the loss coming predominantly from the male sector. Female enrolment remained steady at just under 5,000 students per annum, whereas male enrolment reduced from approximately 27,000 students in 1995 to around 21,000 students in 2003.

Further tertiary enrolment details can be seen in a report entitled *Patterns of higher education institutions in the UK: Ninth report* (Ramsden, 2010), referred to in their own report and so henceforth in this thesis as *Patterns9*. *Patterns9* is the latest in a series of reports from the *Longer Term Strategy Group of Universities UK* (LTSG). LTSG was launched in 2004, and is a higher education sector-wide body which raises awareness of European Union (EU) issues affecting UK higher education.

Enrolment profiles across a range of academic fields during the years 1994/95 to 2007/08 can be seen in Figure 2.2 which was copied from *Patterns9*[30].

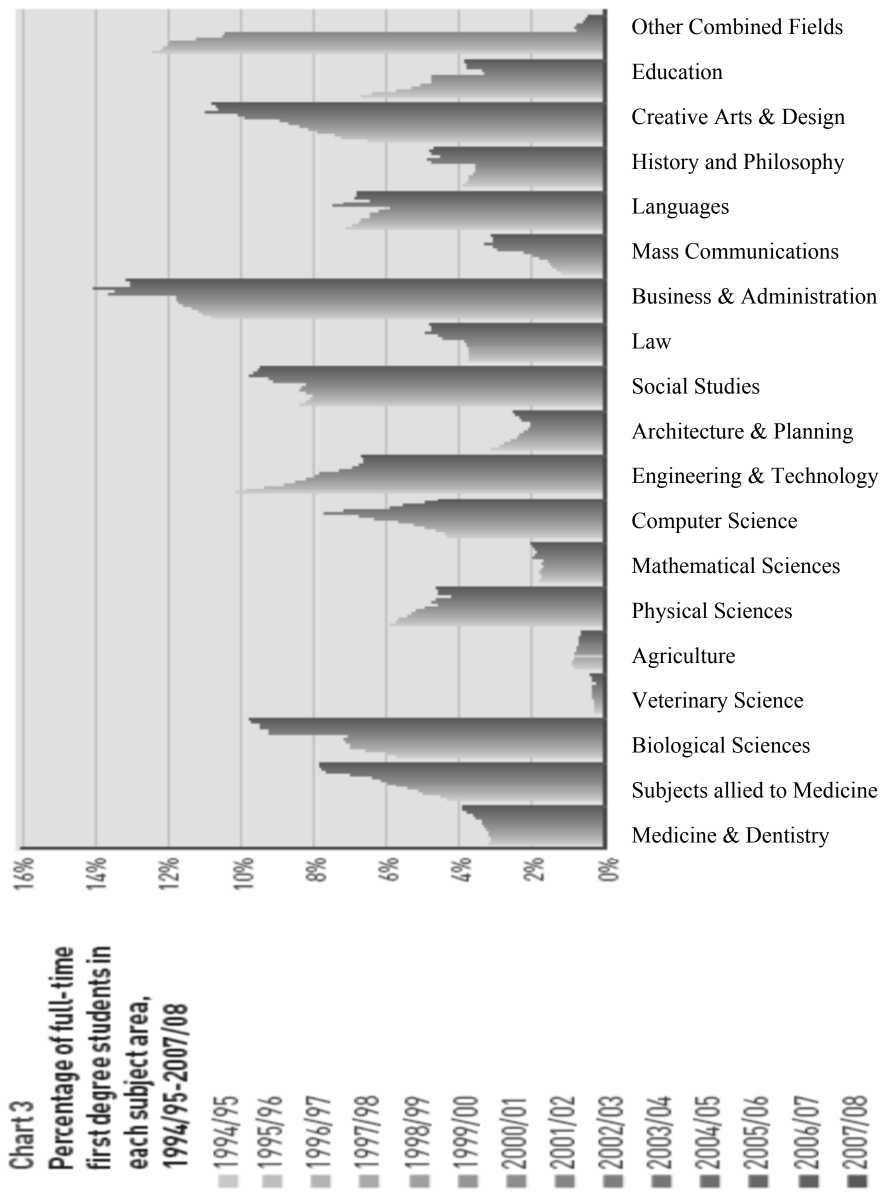


Figure 2.2: Percentage of full-time first degree students in a variety of subject areas in the UK.

[30] Copying permission for non-commercial purposes is expressed on the *Patterns9* report, Ramsden, (2010).

The program enrolment profiles in Figure 2.2 clearly show a decline of uptake into the combined grouping of engineering and technology, from around 10% of the total enrolment in1994 to about 6.5% in 2008. A similar profile showing declining enrolment into the physical sciences is evident during the same period, and although computer science benefitted from a steep increase in enrolment prior to the new millennium, this apparent interest decreased just as sharply from around 2002 onwards. Figure 2.2 shows that the major enrolment gains over the period 1994 to 2008 within the science fields were in subjects allied to medicine, medicine and dentistry, and into biological sciences. In the other fields, the major enrolment gains were seen in the fields of mass communications, business and administration, and social studies, with enrolment onto the creative arts and design increasing by approximately 5%.

Patterns9 also reported that there had been an overall increase of 45% in enrolment into tertiary level programs between the years 1998 to 2008. However, within the 18 categories specified, engineering and technology recorded the lowest enrolment increase with just 9%, as compared with social studies with 61%, creative arts and design with 64%, and mass communications which experienced an increase of about 120%.

Tertiary Enrolment Patterns within the US context

Despite an overall increase in undergraduate students, the 1990s saw enrolment into Bachelor of Engineering degrees in the US decline by around 13% (Kelly, 2001). In a similar fashion, other industrialized nations, including Japan, Germany and the UK, experienced difficulties attracting students into engineering programs (Baillie & Fitzgerald, 2000; Kelly, 2001; Rubin et al., 2000). Enrolment into science and engineering programs in the US did increase around the turn of the century, however by 2007 the combined enrolment into engineering and computer science had fallen back below the reported enrolment for 2003. In order to facilitate a more detailed discussion on tertiary enrolment in the US, a selection of data available from the

National Centre for Educational Statistics (NCES) Web site relating to enrolments from 1991 to 2007 is reproduced in Table 2.1.

Table 2.1: Selected Enrolment Statistics in Science and Engineering Programs in the United States, 1991-2007 (NCES 2011, Table 233)

Year	Engineering	Physical Sciences	Mathematical Sciences	Agricultural & Biological	Health Fields	Computer Science	Environmental Science	Other Sciences	Total Enrolment
1991	113,576	34,710	19,952	63,284	58,565	34,610	14,480	132,085	471,262
	24.1%	7.4%	4.2%	13.4%	12.4%	7.3%	3.1%	28.1%	100%
1998	100,038	30,575	16,719	68,908	79,578	35,991	14,548	139,270	485,627
	20.6%	6.3%	3.4%	14.1%	16.5%	7.4%	3.0%	28.7%	100%
2003	127,375	34,298	19,465	77,881	92,632	53,678	14,655	147,137	567,121
	22.5%	6.1%	3.4%	13.7%	16.3%	9.5%	2.6%	25.9%	100%
2007	131,676	36,824	20,975	85,360	103,300	48,246	14,100	178,938	619,419
	21.2%	5.9%	3.4%	13.8%	16.7%	7.8%	2.3%	28.9%	100%

Note. Data source: nces.ed.gov/programs/digest/d09/tables/dt09_233.asp

The NCES data for the period 1991 to 1998 indicated that some student enrolment preferences appeared to move from the fields of engineering, the physical sciences and the mathematical sciences, to the fields of agricultural and biological sciences, and also to the health fields. The fields of computer science, environmental science, and other sciences showed similar enrolment at both the beginning and end of that period. Despite an overall increase of about 14,000 students in the science fields during the period 1991 to 1998, enrolment into the more mathematically based programs such as physics, mathematics, and engineering fell by around 20,000 students. Kelly (September 2001) likewise reported in IEEE Spectrum that the available figures indicated this migration of students, and that interest in studying electrical, electronic and mechanical engineering fell while enrolments in the fields of computers, biomedical and environmental science had risen (Kelly, 2001; Wheaton, 2001).

Enrolment into science and engineering programs in the US then increased. From a total enrolment of 485,627 in 1998, the absolute enrolment figures into science and engineering programs grew consistently, resulting in over 80,000 additional enrollees by 2003, and a further increase of over 50,000 by 2007. Enrolment into science programs had increased in total to 619,419 students. Engineering benefitted from an additional 31,000 students during the period 1998 to 2007, which was an improvement on the 1998 situation in absolute terms, but as a percentage of total enrolment into science and engineering programs, the proportional enrolment into engineering was back down to within 0.6% of the 1998 figure and to 2.9% below the 1991 figure.

The 2007 enrolment figures published by the NCES in 2011 and shown in Table 2.1 indicate another phenomenon, in this case with respect to enrolment into the field of computer science. Computer science, which has many parallels with the software and programming areas of engineering, exhibited enrolment expansion followed by shrinkage both in terms of absolute numbers and as a percentage of total enrolment. In a fashion similar to the UK enrolment into computer science, as reported earlier in *Patterns9* and shown in Figure 2.2, by 2003 computer science enrollee numbers had risen to 53,678, which represented 9.5% of the total science enrolment in the US. By 2007 however, computer science enrolment was down again to 48,246, which at 7.8% of the total enrolment into science programs was approximately the same percentages as seen in 1991 and 1998.

Of additional interest are the snapshot graduation statistics from the US for the years 1994/1995, 1999/2000 and 2004/2005. The graduation data of selected fields are reproduced as a chart in Figure 2.3. Although these are discrete samples and not continuous figures over each of the ten years, they are related to enrolment into bachelor degree programs which must have taken place a few years earlier. Hence these graduation statistics give an indication of changes in enrolment preferences in the US as well as student persistence and completion.

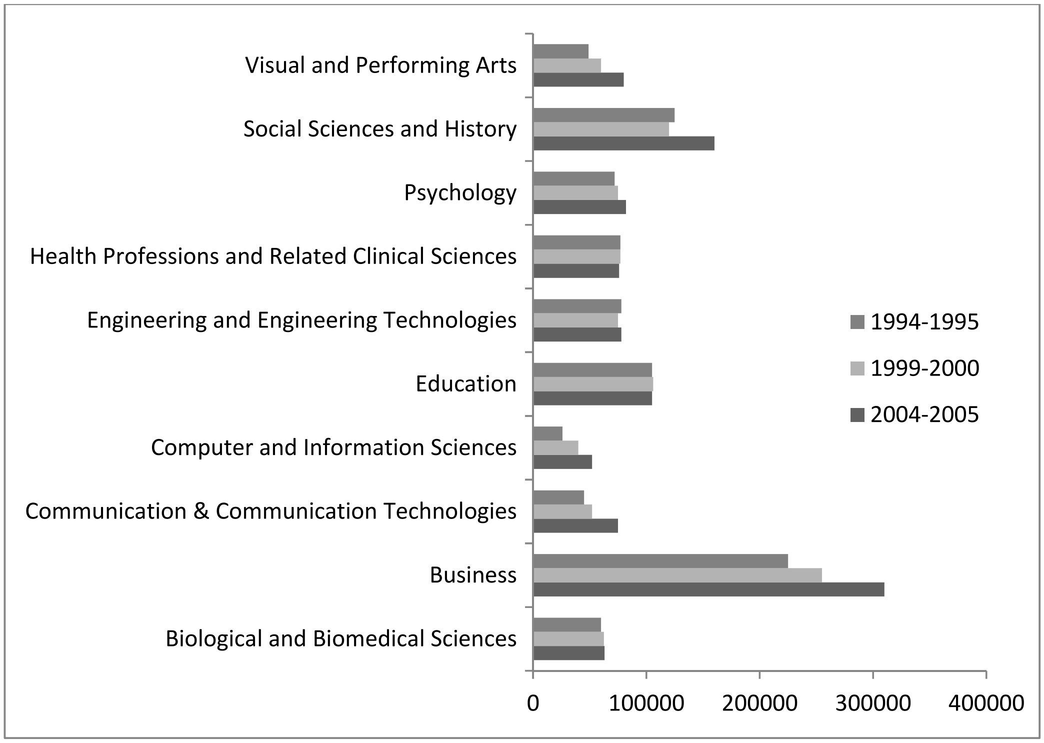


Figure 2.3: Trends in bachelor's degrees conferred by degree-granting institutions in selected fields of study: 1994–95, 1999–2000, and 2004–05.

Source: http://nces.ed.gov/programs/digest/d06/images/fig15.jpg; used with permission

The data of the graduation chart of Figure 2.3 show that while the number of degrees awarded in the fields of business, communications and communication technologies, computer and information sciences, social sciences and history, and visual and performing arts increased considerably during the years shown, the number of graduates from the field of engineering and engineering technologies remained relatively unchanged.

The enrolment data reported by the NCES in Table 2.1 of this work and the graduation snapshots shown in Figure 2.3, also include foreign students. Students numbers that were reported a decade ago as increasing in the US by Coy and Whalen (2001). However in more recent times, Wadha, Saxenian, Freeman, and Salkever (2009) noted in their report entitled *Losing the World's Brightest and Best*, that foreign students within science and engineering programs intended leaving the US after graduation in numbers which, based on historical norms, appeared to be higher than expected. Given that foreign students are included in the NCES enrolment statistics reproduced in Table 2.1, and that as reported by Wadha et al. (2009) many return overseas after completing their studies, it can be concluded that the number of professional engineers available to the US industrial sector declined to an even greater extent than might have originally been perceived from an examination of the NCES data.

Tertiary Enrolment Patterns within the Australian Context

Australian tertiary enrolment statistics were available online from the Australian Department of Industry, Innovation, Science, Research, and Tertiary Education, through their website entitled *uCube*[31]. The data indicated in broad terms that the number of domestic Australians enroling for undergraduate studies increased from 528, 973 during 2003 to 593,911 in 2009; a percentage enrolment increase of approximately 12%.

Tertiary enrolment numbers of domestic Australians into broad fields of study between the years 2003 to 2009 were extracted from *uCube* and converted into percentages of total annual enrolment, as shown in Table 2.2. The categories of enrolment reported through *uCube* were slightly different from those used by the New Zealand MOE shown earlier in Table 1.1, and so to aid comparison with the New Zealand situation the Australian statistics have been combined where possible to align with the headings originally used in the reporting of the New Zealand statistics. For example, two of the academic fields reported in *uCube* were under the separate headings of *IT,* and *Engineering and Related Technologies*, these fields were combined under the heading of *Engineering and IT*, as previously used in Table 1.1.

[31] Retrieved from: *www.**highereducationstatistics**.**deewr**.gov.au/*

Table 2.2: Enrolment into Fields of Study in Australia 2003-2009

Year		Engineering and Related Technologies and IT	Society and Culture	Creative Arts	Natural Sciences	Health fields	Management & Commerce	Other Programs
2003	Student enrolment as % of total enrolment of 528,973 students	15	28	8	10	13	21	5
2005	Student enrolment as % of total enrolment of 528,450 students	12	28	8	10	14	21	7
2007	Student enrolment as % of total enrolment of 557,666 students	11	28	9	10	16	21	5
2009	Student enrolment as % of total enrolment of 593,911 students	11	28	9	10	17	21	4

Note.

Data source: Australian Department of Industry, Innovation, Science, Research, and Tertiary Education - *uCube*

The percentages shown in Table 2.2 indicate that while total tertiary enrolment increased in Australia by approximately 12% between the years 2003 and 2009, the percentage of students enrolling into society and culture and into management and commerce remained steady, and enrolment increases were seen in the fields of creative arts and health. However, enrolment into the combined fields of engineering and related technologies and IT fell by approximately 4%.

As a comparison of enrolment into different academic fields during the year that the survey for this research was conducted, Table 2.3 shows enrolment by domestic Australian students and also by New Zealand domestic students in 2009; the New Zealand enrolment data have previously been shown as part of Table 1.1.

Table 2.3: Enrolment into Fields of Study in Australia and New Zealand in 2009

Academic Field	Domestic Australian Students' Fields of Enrolment in 2009 (%)	Domestic New Zealand Students' Fields of Enrolment in 2009 (%)
Engineering and IT	11	6
Society and Culture	28	31
Creative Arts	9	10
Natural Sciences	10	12
Health fields	17	13
Management & Commerce	21	16
Other	4	12
Total	100	100

Note.

Data sources:

1. The Department of Industry, Innovation, Science, Research, and Tertiary Education – *uCube*
2. The New Zealand Ministry of Education Tertiary Enrolment Statistics

The data of Table 2.3 indicate that engineering and IT were the fields of preference for 11% of the Australian students, second lowest of the specified fields, creative arts being the lowest with 9%. Similarly to the New Zealand students, Australians favoured society and culture and management and commerce for their 2009 enrolment with 28% and 21% respectively.

Gender-based enrolment numbers into engineering and related studies in Australia were also available through *uCube.* These enrolment figures were converted into percentages and plotted as the chart of Figure 2.4. It can be seen from Figure 2.4 that during the years 2002 to 2011 male enrolment increased from approximately 81% to 85% total enrolment into Engineering and IT, and hence the enrolment gap between males and females increased from 62% to 70% in approximate terms.

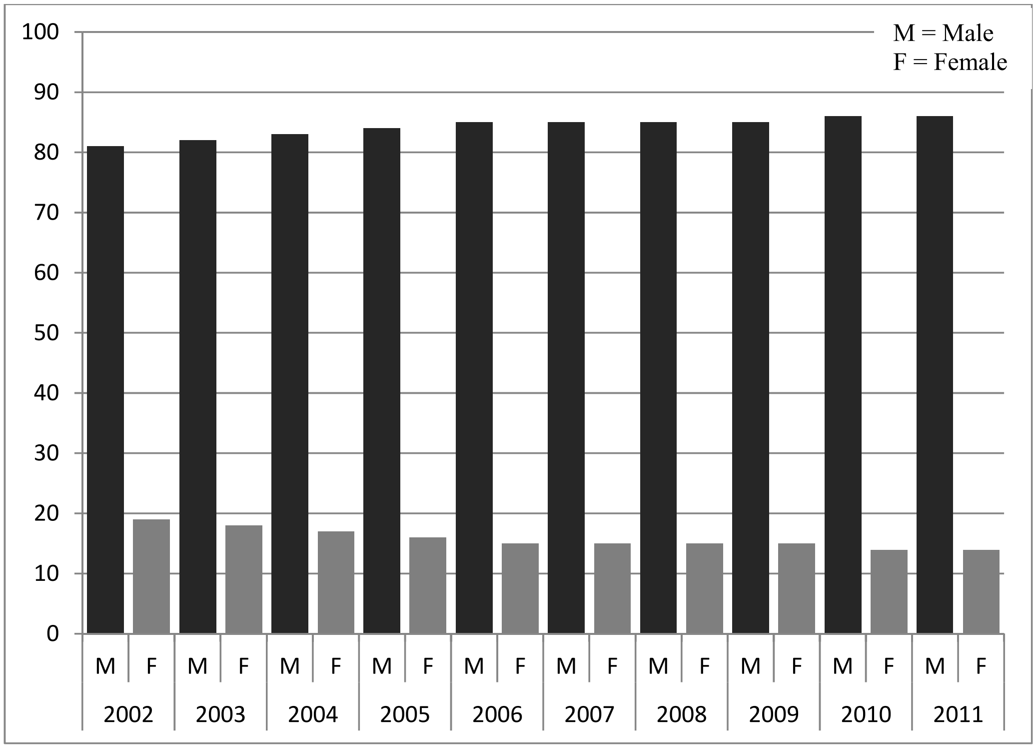


Figure 2.4: Male and female enrolment into engineering and related technologies within Australia 2002-2011 (%)

The pattern shown in Figure 2.4 is similar to the male and female enrolment reported from the UK and previously shown as Figure 2.1, again approximately four times as many males selected engineering and related technologies than did their female counterparts. Such an enrolment pattern also aligns with the sentiments of the Open Mind Research Group (OMRG) report for the Victoria state government (OMRG, 2009), which stated that of the students who showed a preference for ICT-related careers, “Male students were much more likely than female students to pursue ICT studies after secondary school” (p. 12), by a ratio of greater than 3:1.

Having discussed the actual and intended enrolment into post-secondary fields of study across the UK, the US, and Australia, factors which have been found from previous research to affect enrolment are the topic of the following section of this thesis.

FACTORS AFFECTING ENROLMENT INTO BACHELOR OF ENGINEERING DEGREE PROGRAMS WITHIN THE CONTEXT OF SELECTED WESTERN INDUSTRIALIZED NATIONS

Reasons for the decline in engineering enrolment experienced by many nations have been topics of interest to researchers, governments and engineering institutions. More than 15 years ago at the time of writing, Steele and Barling (1996) suggested that the global decline in engineering enrolment was complex, and was associated with factors including ethnic and family influence, and gender. Other researchers concluded that encouragement of others, academic achievement, salary, the working environment, intellectual stimulation, and career aspirations could also influence career choice (Arbona, 2000; Shipp, 1999). For their research in 2001, Morgan, Isaac, and Sansone targeted US college freshmen, the equivalent of New Zealand Year 12/13, as they considered that was the point where students have an abundance of educational choices and are aware of the importance of career decisions.

In the UK in 2007, The Royal Academy of Engineering, UK (RAE) commissioned research into the attitudes towards, and perceptions of, engineering and engineers by the general public (Marshall, McClymont, and Joyce, 2007); in Australia, OMRG canvassed Victorian school students in 2009 on behalf of the state government in order to better understand the students' perceptions of the ICT industry and their attitudes towards ICT as a career choice; and finally for this list of research activities, in New Zealand, Schagen and Hogan (2009) prepared a report entitled *Why engineering, technology, or science?*, to assist IPENZ better understand the motivation behind the tertiary students' study and/or career selection. Schagen and Hogan (2009) canvassed first-year students already enrolled in the fields of engineering, technology, and science, and data were collected online from six universities and eight polytechnics. They received responses from 1,148 students, and their sample consisted of approximately 60% Pākehā, 26% Asian, 8% Māori and Pasifika[32], and 6% Others. It should be noted however, that by canvassing only

[32] Pasifika refers to those peoples who have migrated from Pacific nations and territories to New Zealand, or who identify as Pasifika, via ancestry or descent (Airini, Mila-Schaaf, Coxon, Mara, & Sanga, 2010).

students who had already enrolled into engineering and related programs, the research by Schagen and Hogen (2009) did not collect data related to the career choices of students from other academic fields.

To briefly summarize the results of these reports, the researchers found career choice to be associated with a variety of factors including internal influences such as gender and/or cultural background; external influences such as might come from family, friends and/or careers advisors; academic achievement and the anticipation of interesting work; and other factors such as salary and status. The pertinent findings from these reports and other research will now be discussed in greater detail.

Internal Factors on Career Choice

Internal factors which might influence a student's career choice are considered, from the perspective of this research, to be those factors that are a part of the respondent, for example cultural background, and gender.

Cultural Background

A report in 2008 to the Nuffield Foundation by Osborne and Dillon, entitled *Science education in Europe: Critical Reflections,* indicated some factors which could be relevant to New Zealand's tertiary enrolment. The report calls on information from the *Third International Mathematics and Science Study* (TIMSS) and also by Sjøberg and Schreiner (2005) from their key findings from the *ROSE project (Relevance Of Science Education*). The researchers investigated possible linkages between a nation's achievements, for example their students' ability at science or a nation's position on the United Nations Human Development Index (UNHDI), and the attitudes of students towards science. Osborne and Dillon (2008) presented a scatter diagram of countries' showing the relationship between students' science scores and their attitudes towards science, and this diagram has been redrawn by the author as Figure 2.5. In addition to the relative positions of the selected countries, the diagram also contains a trend line of the participating countries' science score and positive attitude towards science score, and the *International Average*, a point which represents the average of both the science scores and the positive attitude towards science scores.

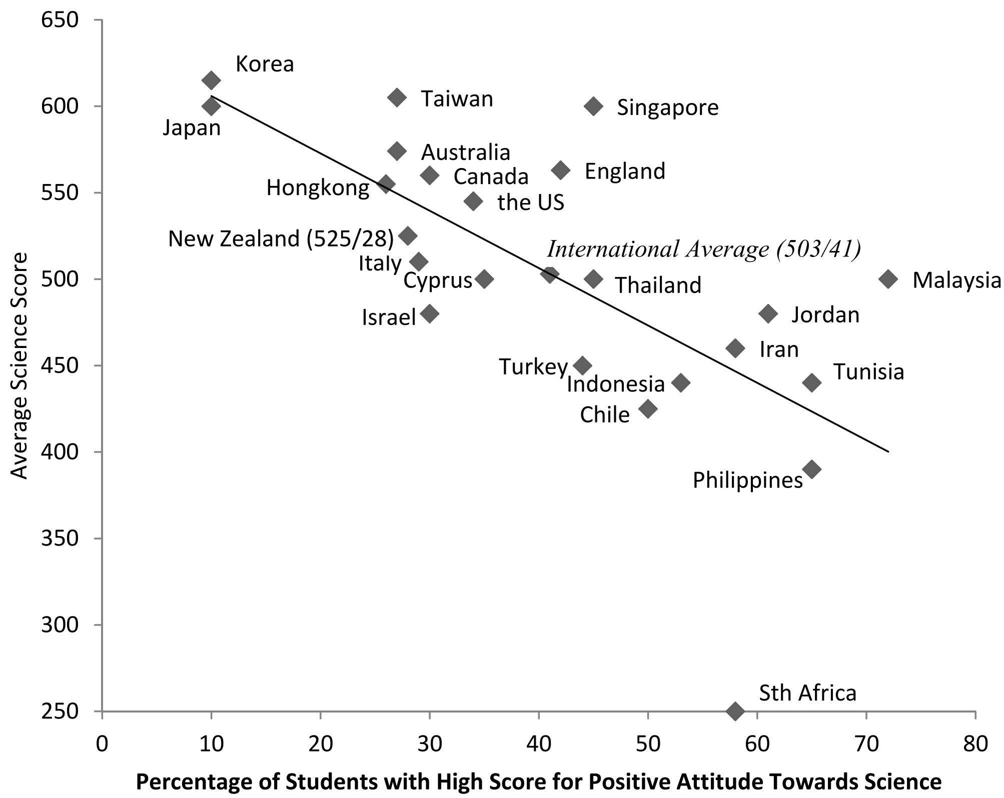
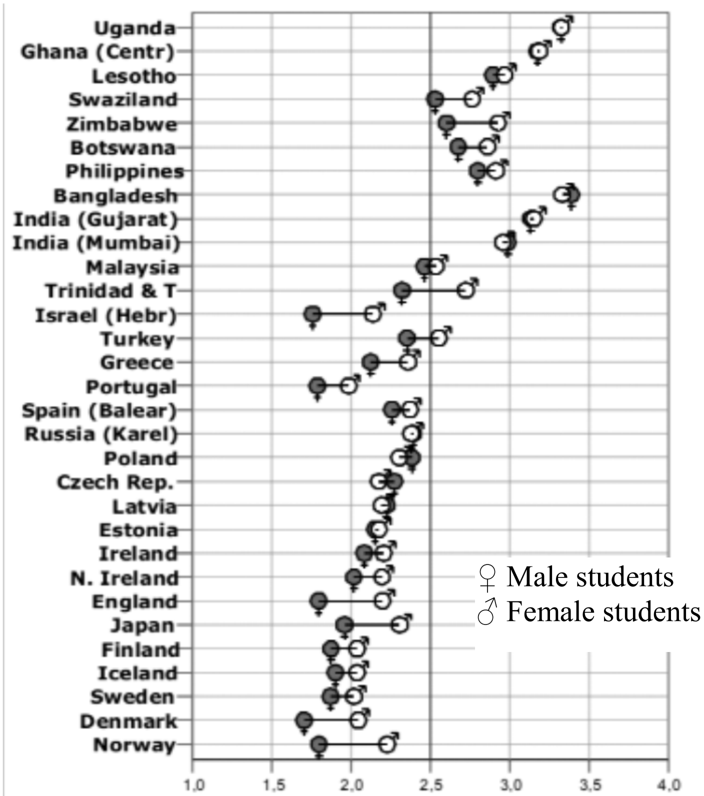


Figure 2.5: Relationship between student achievement at science and student attitudes towards science.

The pattern of Figure 2.5 suggests that for the nations selected, students from a nation which had a high average score for student achievement at science, appear on average to be less interested in science than those students from nations whose students achieved a lower score in science. It can also be seen from the pattern of Figure 2.5 that the youth of New Zealand in 1999 responded in a similar manner but below the international averages. Although the score at Mathematics by New Zealand students (525) was above the international average of 503 for the reported nations, their apparent average of high positive attitudes towards science of 28% was well below the international average of 41%.

Osborne and Dillon (2008) also reported on the work by Sjøberg and Schreiner (2005) who had investigated how learners from different cultures relate to science and technology. Sjøberg and Schreiner (2005) found a negative correlation at the level of 0.92 between a country's position on the UNHDI and mean score responses from 14- to16- year-old school students to the question *I like school science better than other subjects*. The diagram from the report by Sjøberg and Schreiner (2005) is shown as Figure 2.6.



Country average of students' responses which had been placed on a 4-point Likert scale

Figure 2.6: Information from the ROSE study showing student's responses to the question "I like school science better than most other school subjects"[33].

The students were asked to respond using a 4-point Likert scale, where *agree* was coded as 4 and *disagree* coded as 1: thus giving a mapping neutral of 2.6. The patterns of Figure 2.6 show the negative correlation suggested by Sjøberg and Schreiner. For example, school students from Uganda, which is lower on the

[33] Copying permission for non-commercial purposes is expressed on the *ROSE* web site. Retrieved from http:// http://www.roseproject.org/

UNHDI than Norway, responded more positively to the notion of liking science better than most other school subjects, than did school students from Norway. Figure 2.6 also contains information on the responses by the different sexes, shown using the standard icons. For example, the male students from England indicated greater agreement than their female counterparts in liking science, by averaging about 2.2 as compared to approximately 1.8. However, both sets of English students were on the disagree side of neutral. The patterns shown on Figure 2.6 also suggest that for most of the nations selected for this study, boys were more positive than girls in their responses to liking school science more than other subjects.

Commenting on the results from the TIMSS and Sjøberg and Schreiner (2005), Osborne and Dillon (2008) suggested that "One interpretation of these data sets is that this is a phenomenon that is deeply cultural" (p. 14). Although New Zealand does not feature in the report from Sjøberg and Schreiner, it is ranked on the UNHDI and also has strong cultural links with England, which was part of the ROSE project and does appear on Figure 2.6. Given the strength of the correlation (-0.92), some similarity of student responses is expected from other nations with a *Human Development* ranking similar to that of New Zealand. The Human Development Report[34] (UNDP, 2008) ranks New Zealand 19th out of a total of 177 countries on their human development index (HDI), just below England in 16th place. Such ranking, when related to the ROSE project, would suggest that UK and New Zealand should have similar statistics for students engaged in school science courses. That is to say, both should have a low average score on the scale of liking school science. As previously discussed however, the data of Table 1.3 suggests that New Zealand youth are not deserting science at school, and that enrolment into physics, chemistry, and biology exceeded enrolment into subjects such as accounting and computer studies for the years sampled.

The results of the ROSE project shown on Figure 2.6 seem to treat the country's population as homogenous with respect to ethnicity. New Zealand has an ethnically

[34] Retrieved from http://hdr.undp.org/en/statistics/

heterogeneous population, as indicated by the government Web site for the Department of Labour[35]. Immigration for 2009/10 came predominantly from China, South Africa, and the UK, with India providing the largest proportion of international students. This last fact is relevant to this research in that India does appear on Figure 2.6 and with two interesting factors: a high proportion of the Indian students indicated they were more interested in science than other subjects, and, unlike the majority of the response patterns shown, Indian males and females responded in very similar fashion. Given New Zealand's profile of immigration it is possible that children of recent immigrants, of whom Indians form a considerable portion, are complicating the relationship between the studying of science in school and the subsequent enrolment into engineering degrees. Consequently, information relating to the respondent in terms of their family's arrival in New Zealand and their cultural/ethnic background appear to be germane to this research.

Women in Engineering and Technology

The under-representation of women in engineering and related technologies, and the consequent focus by a number of institutions internationally to redress the balance, has been briefly discussed in Chapter 1 of this thesis. Further to that discussion is the research around the beginning of this century conducted by Adams (1998), Dainty, Neale, and Bagilhole (1999), and Arbona (2000), and a decade later, research which formed the basis of reports to and from the US, the UK, and Australian governments. Dainty et al. (1999), who surveyed engineering professionals, found women to be under-represented at all levels of the construction industry, most noticeably within management. They concluded that in general women had been influenced to enter the industry by focused recruitment campaigns rather than advice from friends or family. Dainty et al. (1999) also found many women were disillusioned by the lack of career opportunities and so were considering leaving the construction industry. Adams (1998) had focused on the

[35] Retrieved from http://www.dol.govt.nz/publications/general/migration-trends-outlook/2009-2010/at-a-glance.asp

research of gender-related differences in mathematics, reporting that American males were more confident and had more positive feelings about mathematics than did females. Likewise Arbona (2000) in an article reviewing career literature published in 1999, concluded that girls showed less interest and confidence in mathematics than did boys, and the major barrier for white female students entering science programs was their attitudes and their early subject choices at school.

More recent research has found no sustained changes in the gender imbalance within the engineering fraternity. Figure 2.1, previously discussed in this chapter within the context of falling enrolment into engineering programs in the UK, showed male enrolment outnumbering female enrolment during the years 1995 to 2003 by a ratio of approximately 5:1 respectively. In Europe, the *SESTEM* project (*Supporting Equality in Science, Technology and Mathematics related choices of careers*) was the collaborative research project of a consortium of universities from the UK, France, Germany, Greece, Spain and Poland, funded by the European Commission. A summary of the report (National Report UK, 2012[36]) indicated that females accounted for fewer than 12.2% of the management and 7% of engineering professionals. The report also revealed that of science, technology, engineering, and mathematics (STEM) graduates who take up a job in STEM fields, only 30% are female compared with 50% among males.

The tertiary education statistics released by the statistics department of European Commission (Eurostat), as shown in Figure 2.7, also revealed that in terms of the enrolment of males and females into different academic programs, a similar situation had also existed Europe-wide in 2009.

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[36] No author was identified for this report which is located on the SESTEM Web site.

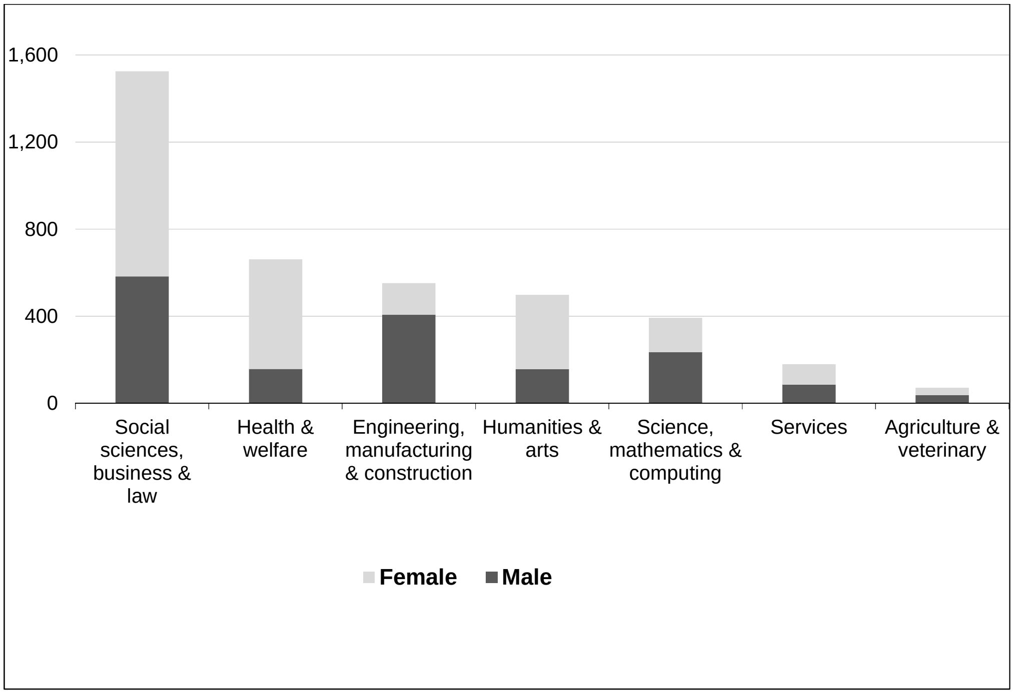

Figure 2.7: Graduates from tertiary education, by field of education and gender, EU-27, 2009.

Source: http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Tertiary_education_statistics

The patterns shown in Figure 2.7 indicate that Europe-wide, similar or greater numbers of females than males graduated in all fields apart from science, mathematics and computing, and most noticeably the field of engineering, manufacturing and construction, where male graduates outnumbered females by around 4:1.

Similar ratios were reported from the US by the National Science Foundation report (NSF, 2011), which indicated that from 1993 to 2008, male enrolment into engineering degrees proportionately outnumbered female enrolment in the order of 5:1. Even more recently is the research by Nguyen and Pudlowski (2012). In their paper for the World Institute for Engineering and Technology Education conference, Nguyen and Pudlowski (2012) also showed that similarly in Australia, male enrolment into university engineering and technology disciplines had consistently outstripped female enrolment by a ratio of about 5:1 during the years 2005 to 2009.

A number of researchers have attempted over the years to explain the gender imbalance in engineering. The impact which computer games, initial computer experiences and advertising had on males and females was discussed by Miller, Wood, Halligan, Keller, Hutchinson-Pike, Kornbrot, and deLotz (2000). They contended that computers were bought predominantly for males rather than females, and that many early computer games were combat-related which appealed to males rather than females. A review of computer-related advertising indicated the tendency to use images of males working with computers with females cast in a more decorative role. More recently Morganson, Jones and Major (2010) researched into social coping among undergraduates. They reported that the STEM environment was often described as chilly, impersonal, male dominated and individualistic. They suggested that the lack of support in the STEM environment may be particularly harmful to women, and concluded that there were implications for counselors and policy makers in terms of creating a supportive and collaborative environment. Nicholson, Ridgway, and McCusker, (2011), in their synthesis of the results from the SESTEM project, make similar conclusions. They suggest that STEM careers are perceived as posing problems for work-life balance, "and that working environments can be individualistic and competitive; these perceived features are disincentives for many people, notably women" (Nicholson et al., p. 80).

External Influences on Career Choice

External influences from the perspective of this research can be considered as personal interaction with others, for example a discussion with a family member or school advisor, or other influences such as advertising, subject choice at school, and science and/or engineering promotion schemes, which may deliberately or accidentally affect the students' career choices.

Family, Friends, and Advisors

There is agreement from the research findings reviewed that personal interaction has a bearing on students' career decisions. In the US, *The Science Daily* reported on work by Jon Miller and colleagues of Michigan State University (Parents Still Major

Influence On Child's Decision to Pursue Science Careers, 2010)[37]. The researchers used data from the Longitudinal Study of American Youth (LSAY)[38], which tracked nearly 6,000 students from middle school and through college in the US, with the intention of attempting to determine what had influenced their career choices. The *Science Daily* article indicated that Millar and colleagues concluded the home environment was particularly influential especially where students were encouraged to go to college. In the UK, a review of the literature related to career-related interventions was conducted in 2005 by Bimrose, Barnes and Brown of Warwick University. Bimrose et al. (2005) selected 56 empirical studies on which to base their report, part of which focused on extra-curricular interventions. Their research indicated "Family members working in the engineering sector emerged as a significant influence on women's decisions to study and enter engineering" (p. 38).

In Australia the authors of the OMRG study (2009) concluded that the principal influences on career choice were likely to be people working in the field, the students' parents, and the students' work experience (p.15). The researchers also concluded that males were much more likely than females to pursue careers in ICT (p. 12). To the contrary however, Schagen and Hogan (2009) found that family and friends in New Zealand were ranked one third of the way down a table of 15 possible sources of careers information. When asked to indicate how helpful the sources of their career information had been, the first-year tertiary students indicated that talking to people working in the field was the most helpful, and similar responses were afforded to personal research through the internet and/or watching subject-related programs. Suggestions from family and friends were ranked 4/15 and 5/15 respectfully in terms of being helpful, while towards the bottom of the ranking was presentations at school, considered as one of the least beneficial sources of information with a ranking of 14/15.

Preparation for a Career in Engineering and Related Programs

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[37] Retrieved from http://www.sciencedaily.com/releases/2010/02/100220204814.htm

[38] http://lsay.org/

Academic Preparation at School

Student preparation for enrolment into undergraduate science programs has been reported through a number of sources, and for more than a decade has drawn comment from researchers from the US, the UK, and Australia. Bellinger (1997) and Rubin et al. (2000) indicated that some of the students they consulted gave their reason for not pursuing science degrees as feeling that they were poorly prepared in mathematics and science; Campbell (in Bellinger, 1997) commented that fewer than 15% of American students were sufficiently educated to pursue science majors at college; Adams (1998), also reporting from the US, concluded that males, more so than females, were confident and had positive feelings about mathematics, and that parental influence on mathematics was more likely to be negative towards a daughter and positive towards a son. In research findings published in the US around the turn of the century, Morgan et al. (2001) indicated that in the USA, the freshman year is the point where the greatest loss of women to the mathematics/science pipeline occurs. More recently, data from the NCES in the US (January, 2011) showed a decrease in score by 12th grade students in science courses from 1996 to 2005, as well as indicating that males outperformed females during that period. The NCES has been tracking the performance of school students since 1985. Their latest report at the time of writing this thesis (NCES, 2011) indicated that during the years 1996 to 2005, the national average 4th-grade science score increased; there was no measurable change in the 8th-grade score; and the 12th-grade score decreased. Their report also stated that males outperformed females at all three grade levels.

In Europe, the SESTEM project was the collaborative project of a consortium of universities from the UK, France, Germany, Greece, Spain and Poland. The UK report summary revealed that the largest gender disparity in university enrolment occurs in the engineering and technology subjects, and suggested that an underlying factor is subject choice at A-levels[39]. The report indicated that although boys and girls followed largely similar tracks, the migration from STEM subjects by girls was

[39] A-levels in the UK had a time frame approximately equivalent to New Zealand Year 12 plus Year 13.

very apparent at aged 16. Girls generally outperformed boys at the end of compulsory education (equivalent to New Zealand Year 11), however, the enrolment into A-level physics was about four times greater for boys than for girls. Given that A-level physics is closely related to most engineering courses and frequently requested as a prerequisite for enrolment, the ramifications of subject choice may not be fully understood by students until it is too late.

From Australia, the 14- to 19-year-old Victorian students did not indicate they felt under-prepared for ICT. Given eight specific options for not studying ICT including *I prefer other subjects, It doesn't interest me,* and *It's too hard*, the *It's too hard* option received the least agreement (OMRG, 2009, p. 16). That is to say, the Victorian students felt academically capable of studying ICT. In New Zealand the research by Schagen and Hogan (2009) did not specifically comment on academic preparation. It did however report that the respondents indicated being good at the subject was important, and so, given they were researching first year engineering, technology and science undergraduates, it follows that at least those students were likely to have felt that they were academically prepared for their programs.

Knowledge, Sources of Knowledge, and Perceptions Related to Engineering

Knowledge about a particular career can be gained from a multitude of interpersonal and impersonal sources, and when asked specifically about where they would seek information on engineering, the 16-year-old to 19-year-old participants of the RAE research conducted by Marshall et al. (2007) indicated that the internet was the preferred choice of the majority. Older members of the research sample indicated preferences towards libraries, family and friends, and job centres. Word of mouth from family and friends who had done an engineering degree and/or worked in the industry was considered by the majority of the sample as the most reliable source of information. Despite the apparent availability of data however, Marshall et al. (2007) concluded in their executive summary that of those who professed awareness of engineering, it "tended to be narrowly defined and primarily related to construction and manual professions", (p. 3). In general, Marshall et al. (2007)

found that there were doubts in their participants' minds about the accuracy of their own knowledge of engineering, brought on by a lack of clarity of what constitutes engineering. This lack of understanding seemed especially prevalent among the younger respondents who felt that the term *engineer* was misused to make a job sound better, "used in job titles or to describe types of work that did not fall under the umbrella of engineering in order to raise their profile" (p. 22). That lack of clarity in the UK is not dissimilar to the situation in Victoria, Australia, where the OMRG research (2009) revealed that among other things, the students felt that they did not have enough information about ICT careers. More than half of the students indicated that they knew very little about it, but unlike their UK counterparts, the Victorian students also claimed that they had experienced difficulty locating course information via the internet.

Other Influences on Career Choice

The potential importance of either having an interest in a program of study, or the expectation of having an interesting career, has been the focus of a number of research activities. Research by Baillie and Fitzgerald (2000) revealed that potentially high achievers were dropping out of Imperial College, London, for reasons which included not being sufficiently challenged and not being able to be top of the class. Other students were reported as indicating that they found the courses to be too theoretical and lacking in opportunities for individual pursuit. Jill Tietjen, Dean of Engineering at Colorado University, as reported by Kelly (2001), indicated that she thought students were "bombarded" with such gateway courses as calculus and physics, without doing any courses which might normally be considered as fun. Morgan et al. (2001) researched the role of interest in career choice, that is to say the expectation that a career will be interesting. They noted that despite the narrowing gender-related performance gap in mathematics and science of American students, the gender-related career choice gap in engineering and science persisted. They suggested that factors which contribute significantly towards career decisions for women would be anticipated interest and interpersonal goals, whereas for men, higher pay and status were reported as more influential factors on career selection.

Several years later, further research into the topic of subject interest was reported. In the UK, the report to the Nuffield Foundation by Osborne and Dillon (2008) provided a comprehensive assessment of the state of scientific studies within schools in the Europe. Commenting on the declining interest in school science, these UK authors ask the question which could likewise have been asked about the declining interest in science in New Zealand, Australia and the US:

> "Why is this? Does the problem lie in wider socio-cultural changes, and the ways in which young people in developed countries now live and wish to shape their lives? Or is it due to failings within science education itself?" (p. 5).

Osborne and Dillon (2008) went on to conclude in their report that although most children engage with science during their primary-school years, by the time they leave school they have become alienated towards it. In line with this comment from Osborne and Dillon, Marshall et al. (2007) had previously reported that "a number of the young people attributed their negative perceptions [towards engineering as a career] to a lack of interest" (p. 28).

In Australia, the report by the OMRG to the Victorian state government in 2009 likewise concluded that when choosing future careers, students placed most importance on jobs that they felt would be interesting and at which they expected to be good. At a similar time in New Zealand, Schagen and Hogan (2009) showed that in response to 15 questions regarding reasons for choice of subject, 83% of the first year students sampled concurred with their US and Australian counterparts; indicating subject interest had been a strong reason for their tertiary program choice.

The notion of status and its association with different careers such as engineering has also been investigated by many researchers. To students in the US, Morgan et al. (2001) concluded that engineering was perceived as a high pay and high status career, a notion which was echoed more than a decade later by The Chartered

Institution of Highways & Transportation (CIHT) in the UK, who claimed that "High status is attached to the CEng and IEng qualifications"[40], and by Baranowska and Unt (2012), who concluded from their research into employment within Western Europe, graduates from engineering may enter high status jobs at the end of their education and training. However, such observations are not entirely consistent with the findings of all researchers. Rojter (2009) of Victoria University, Melbourne, when researching the reluctance of senior secondary students to choose engineering as a course of study, suggested that the engineering profession was not well marketed to the public in general, and that they are not visible as an occupational group. Rojter (2009) also suggested the curricula for engineering programs needed to become more vocational rather than applied science.

ACTIVITIES AIMED AT IMPROVING ENROLMENT INTO ENGINEERING DEGREE PROGRAMS WITHIN THE CONTEXT OF SELECTED WESTERN INDUSTRIALIZED NATIONS

A number of initiatives have been taken internationally over the years in an effort to revitalise engineering enrolment. Kubel (2001) reported on awareness programs for K-12 students, and an online guide to becoming an engineer posted by The National Action Council for Minorities in Engineering[41]. At a similar time, Rubin et al. (2000) discussed the closer links between industry and education, and the inclusion of an engineering education program from the US Military academy. Kelly (2001) reported that educational institutions such as Smith College, Massachusetts and the University of Applied Sciences, Solothurn, Switzerland were moving towards more project-based curriculum, and away from the traditional first year engineering program dominated by mathematics and physics.

The persistent under-representation of women in engineering in the US was still of sufficient concern in 2006 however, to have motivated the National Association of Engineers (NAE), the Institute of Electrical and Electronics Engineers (IEEE), and

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[40] Retrieved from http://www.ciht.org.uk/en/education--training/becoming-ceng-ieng/

[41] Retrieved from http://www.nacmebacksme.org/NBM_B.aspx?pageid=18

the American Society of Mechanical Engineers (ASME)[42] to collaborate on the *Gender Equity Extension Service Project*[43]. The aim of the project was to increase enrolment and retention of women into engineering programs, and the strategy employed was for those from the engineering fields to engage directly with students and teachers: master teachers and engineers working within existing academic structures to promote their own profession. The NAE Web site *Engineer Girl!* was also upgraded in 2006 with newer technologies including, streaming video and podcasts, a section named *why be an engineer*, links to other engineering-centric information, a section highlighting women engineers, and also advice regarding school subjects.

In summary of this chapter and with consideration of the New Zealand context introduced in Chapter 1, much of the industrialized world experienced an overall decline in enrolment in Bachelor of Engineering programs over the decade 2000 to 2010. Literature from the selected western industrialized nations indicated fewer students were pursuing mathematics and science at school, and significantly fewer females than males chose engineering as a career. Research into career choice has found it to be associated with factors including internal influences such as gender and/or cultural background, external influences such as might come from family and friends, and other factors including academic achievement, the anticipation of interesting work, and salary. International researchers have also indicated that females tended to choose careers such as teaching and nursing which value interpersonal traits, and that males tended to choose careers such as engineering which afford high salary and status.

The New Zealand context seemed to differ from that of the US, the UK, and Australia in terms of the school students' preparation for engineering as a field of study. Unlike the students who were the subjects of reports by researchers, and of

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[42] American Society of Mechanical Engineers http://www.asme.org/

[43] http://www.nae.edu/programs/casee/projects12300/entryportals/eeeshome.aspx

government reports from the US, the UK, and Australia, the New Zealand school students had maintained their enrolment at senior school mathematics and science.

In New Zealand, Pākehā were the largest major ethnic group and also formed the largest proportion of tertiary students with approximately 69% of the tertiary enrolment. However, they had low proportional enrolment (5.5%) into degree programs in the fields of engineering and IT, as compared with their enrolment into programs from other academic fields. Additionally, though females out-perform males academically at school in New Zealand, the trend of females avoiding engineering mimics that of females from other industrialized nations. An increase of approximately 7,000 enrollees into Bachelor of Engineering courses would be achieved if interest in engineering among Pākehā could be increased to the levels shown by Asians, and enrolment by females lifted to the level of enrolment recorded by males. Such an enrolment increase would significantly alleviate the shortage of professional engineers in New Zealand.

It is proposed that research be carried out within the context of New Zealand school leavers in an effort to better understand what motivates their career choice. Whether the decline in enrolment into engineering courses is the result of advice from family, problems of an academic nature, peer pressure, or computer-phobia, it is unlikely to be reversed unless the cause is better understood.

In the following chapter possible research methods for this work are discussed, as are details of the design and implementation of the approach chosen.

CHAPTER 3

RESEARCH METHOD

INTRODUCTION

This chapter argues the design of the research method, the research instrument development, and the sampling technique used in this work to better understand why New Zealand school leavers do, or do not, choose engineering as a career or field of study. The major research questions to be answered are:

RQ1. What do Year 12 students in Greater Auckland know of careers in engineering?

RQ2. What are the attitudes of Year 12 students in Greater Auckland towards engineering as a career or field of study?

RQ3. What factors do Year 12 students in Greater Auckland perceive have influenced their attitudes towards engineering as a career or field of study?

RQ4. Based on the findings of this research, what are the implications for school advisors, and others advising students on the choice of careers in engineering and related technical fields?

The synthesis of the literature in Chapter 2 revealed that the key factors which influence a student’s choice of whether or not to follow a career in engineering, are the student’s knowledge about professional engineering, their career expectations in general, their expectations of engineering as a possible career, and a number of personnel including family, friends, and advisors. Assessment of the students' career-related knowledge and attitudes, and the origins of their knowledge and attitudes would be achieved through the analysis of their answers to a series of sub-questions, the roots of which are shown later in this chapter.

RESEARCH DESIGN

Survey was chosen as the most appropriate research method. A variety of data-gathering methods is available that could elicit the knowledge and/or opinions of the students, for example interviews, attainment tests and questionnaires. The use of interactive data-collection procedures such as face-to-face interviews, telephone-interviews and/or interview-questionnaires were precluded by cost, both in terms of time and money, resulting from the size and geographical distribution of the sample. Attainment tests are described by the National Foundation for Educational Research as test used to assess if students who have completed a course of study, have acquired a requisite level of mastery in the relevant curriculum[44]. It was considered, however, that attempting to assess students' knowledge of engineering by including an additional 'knowledge test' into an already busy school schedule, was unlikely to inspire the necessary level of support from either the students or the teachers. Hence attainment tests were also rejected as a suitable means of data collection.

A self-administered questionnaire is intended to gather data reflecting personal opinion, and so the personal bias inherent in the process does not pose a threat to the validity of the results (Page & Meyer, 2000). The questionnaire itself can either be hard copy or online. Using an online questionnaire is highly efficient as the data entry can be achieved by the respondents themselves. The questionnaire can be designed so that the data entered by the respondents feeds directly into a database from which the raw data can be processed. An online questionnaire is also flexible in terms of access by respondents as, theoretically, they can take part in the survey at any time of day or night and from anywhere in the world.

Surveying an appropriate sample of the school population is a commonly used research method in these circumstances as "surveys gather data at a particular time with the intention of describing the nature of existing conditions ... or determining the relationships that exist between specific events" (Cohen & Manion, 1994, p. 83).

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[44] Retrieved from www.nfer.ac.uk/nfer/research/assessment/assessment-development/attainment-testing.cfm

Using a sampling frame (Kish, 1965; Sekaran, 1992) consisting of those who attend a specific year of school will result in a small amount of information being lost as a result of student illness, truancy and non-completion. It is anticipated however that those missing from the frame do not constitute threats to validity or ethical bias produced by inappropriate sampling (Page & Meyer, 2000).

Random sampling is a technique which provides the greatest assurance that the sample from a population accurately reflects the whole population (Bouma, 1996; Page & Meyer, 2000). This is a statistical 'greatest assurance' however, which likewise acknowledges a statistical possibility that those chosen to be the sample may not be representative of the population. Stratified random sampling is a more refined technique whereby the population is grouped according to some relevant characteristic and then randomly sampled within each grouping. This method reduces the variation of an individual within the sample, and so improves the probability that the spectrum of variations across the population will be represented.

The required sample size is influenced by the size of the population the sample seeks to represent, the number of variables in the data gathering instrument, and the degree of confidence required from the results (Cohen & Manion, 1994; Page & Meyer, 2000). A minimum sample size for inferential statistics is 30 (Bouma, 1996; Cohen & Manion, 1994; Page & Meyer, 2000), however Bouma (1996) suggests that when an analytical matrix is being used, the sample size should be five times the number of boxes in the matrix. Sekaran (1992, p. 253) and IEEE (November, 2010) provide a generalized scientific guideline for sample size and population size: both indicate that to achieve a 95% level of confidence for a population of, for example, around 20,000, the sample size should be at least 377[45].

The sample size available for analysis, however, is the number of correctly completed questionnaires which are returned so that the results of any statistical analysis can be generalized to the whole population with sufficient levels of

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[45] Retrieved from URL: www.ieee.org/about/research/sample.html

confidence. Consideration must be given to the possible proportion of unreturned and/or incorrectly completed and/or "spoilt" forms, in order to determine the minimum number of questionnaires to administer. Anticipating a response rate, for example in the region of 50%, means that double the number of questionnaires would need to be distributed.

In summary, the most appropriate research design in this situation is considered to be an online self-administered questionnaire, completed by senior school students who have been sampled at random from a stratified target population.

Target Population and Sample Distribution

The initial intention of this work was to survey New Zealand Year 13 students, as they are about to enter the employment market and so should be aware of their career options. When a number of schools in New Zealand were approached to take part in the survey however, they showed little or no interest. It was postulated that school staff themselves were already very busy, and also they were protecting their Year 13 students who were fully occupied with final year activities and preparation for their end of year examinations. Year 12 students were considered as an alternative source of information for this work, as they too are potential enrollees into the Bachelor of Engineering degrees, they would likewise be aware of their career options and influences, but they would be under less immediate pressure of final exams than their Year 13 counterparts. Consequently it was decided that students in Year 12 were a valid and suitable target population for this research.

At the time of developing this research, the author and a co-supervisor were residing in the Greater Auckland region and had relatively straight forward opportunities to contact Principals and visit schools. Hence in order to discover why some New Zealand school leavers who are eligible to study for a Bachelor of Engineering degree choose to do so, while others do not, this investigation proposed to survey Year 12 students studying in schools within the Greater Auckland region. Although the Year 12 population of Greater Auckland did not equate to the Year 12 population of New Zealand, with 18,231 students out of a total of 52,920 students, in 2007 it did however represent nearly 35%. While recognizing local characteristics, including the large Pacific Island population in Auckland and the popularity of the city as a destination for overseas students, the attitudes and expectations of the Greater Auckland population were considered likely to be generally indicative of the attitudes and expectations of the New Zealand Year 12 population more widely.

To improve the representative nature of the sample of students, the target population was stratified. The schooling system in New Zealand is broadly divided by their governing authorities, i.e. the totally government funded and partly privately funded sectors. These sectors are then further divided into co-educational, male only, and female only schools. A complication exists where some schools have a single sex junior school and a co-educational senior school, and in these cases the school was included into the co-educational sector. These sectors and school-types within the sectors, then formed the six strata into which the Year 12 population was divided.

To achieve a 95% level of confidence that the results could be inferred to the 18,231 Year 12 students throughout Greater Auckland, the sample size required was taken to be 377[46]. Anticipating a high percentage of returns (50%) because of the secure and controlled school environment meant that 754 questionnaires would need to be distributed. For improved reliability this number was rounded up to 800.

In summary, the target population for this research was students attending Year 12 classes at schools in the Greater Auckland region. Given the resource and time restraints however, it was not feasible to gather data from the entire Year 12 population of Greater Auckland. The students were grouped by school type and governing authority, and a stratified random sampling technique adopted to create a sample of approximately 800 students. Although the Year 12 student population of Greater Auckland is nearly 35% of the New Zealand Year 12 population, the

[46] The data of the IEEE sample size table indicate that for populations of 5,000, 10,000, and 20,000 the sample sizes are 357, 370, and 377 respectively.

anticipated 95% level of confidence in the inferences from this type of research can only be attributed to the Year 12 students of the Greater Auckland region itself.

Sample selection

It was decided that students from the special needs, correspondence, and home schooling sectors should not be included in the survey because of anticipated difficulties in accessing the students, and the possibility of disrupting their classes. At the request of the author, the statistics department of The New Zealand MOE supplied information which indicated 18,107 Year 12 students attended the other schools of the Greater Auckland region in 2007. The distribution of those students within the education sectors of the Greater Auckland region, i.e. the sample strata, is shown in Table 3.1.

Table 3.1: Year 12 Student Population within the Greater Auckland Region for 2007, Stratified by School Type and Schools' Authority

School Authority	School type	Male		Female		Totals	
		n	%	*n*	%	*n*	%
State	Coeducational	6,199	34.2	6,135	33.9	12,334	68.1
	Male Single-sex	1,898	10.5			1,898	10.5
	Female Single-sex			2,120	11.7	2,120	11.7
State Schools sub-Total		8,097	44.7	8,255	45.6	16,352	90.3
Private	Coeducational	766	4.3	533	2.9	1,299	7.2
	Male Single-sex	61	0.3			61	0.3
	Female Single-sex			395	2.2	395	2.2
Private Schools sub-Total		827	4.6	928	5.1	1,755	9.7
Grand Totals		8,924	49.3	9,183	50.7	18,107	100

As a result of the allocation of students who attend schools which have single-sex junior schools associated with coeducational senior schools, the strata populations of Table 3.1 differ slightly from those on the School Roll database for July 2007 (NZMOE, 2007). The reason is that the MOE database includes students from these schools in the 'single-sex' schools total. This research, however, is looking at Year 12 students who are in the coeducational sector of the school. Consequently, for the purpose of this research, Year 12 students attending such schools have been included in the coeducational totals.

Ideally students should be selected throughout the strata in the proportions shown in Table 3.1, for example 274 questionnaires (34.2% of the proposed 800) should be completed by males from coeducational state schools. This would however require the selection of just a few students from each of the Year 12 classes throughout the Greater Auckland region; an approach considered impractical and expensive. Cluster sampling by school class, considering an average class size of 30 students, is a practical approach to this sampling situation and also minimizes potential disruption to schools. Table 3.2 shows the number of classes to be surveyed and the distribution of those classes within the strata.

Table 3.2: Sampling Clusters of Year 12 Classes within Greater Auckland, Based on School Type and Schools' Authority, July 2007

School Authority	School type	Male	Female	Totals
State	Coeducational	34.2% = 274 stds = 9 classes	33.9% = 271 stds = 9 classes	68.1% = 545 stds = 18 classes
	Male Single-sex	10.5% = 84 stds = 3 classes		10.5% = 84 stds = 3 classes
	Female Single-sex		11.7% = 93 stds = 3 classes	11.7% = 93 stds = 3 classes
	State Total	44.7% = 358 stds = 12 classes	45.6% = 364 stds = 12 classes	90.3% = 722 stds = 24 classes
Private	Coeducational	4.3% = 34 stds = 1 class	2.9% = 23 stds = 1 class	7.2% = 57 stds = 2 classes
	Male Single-sex	0.3% = 3 stds = ½ class		0.3% = 3 stds = ½ class
	Female Single-sex		2.2% = 18 stds = 1 class	2.2% = 18 stds = 1 class
	Private Total	4.6% = 37 stds = 2 classes	5.1% = 41 stds = 2 classes	9.7% = 78 stds = 4 classes
	Grand Totals	49.3% = 395 stds = 14 classes	50.7% = 405 stds = 14 classes	100% = 840stds = 28 classes

Table 3.2 shows that working with a base unit of 30 students per class resulted in 14 classes for both the male and female students, and hence a theoretical total of 840 students (28 classes of 30 students) in the sample. Such oversampling is not an issue to the generalizability of the results, provided the ratio of responses between strata is maintained. To maintain the appropriate ratios between the strata once the actual responses are obtained, additional responses in any stratum are eliminated using random selection.

To maximize the sampling representation, the intention was to randomly select schools from the total available in the strata, and to choose only one Year 12 class per school selected. Where a large school with many Year 12 classes was selected, the class to be surveyed would be randomly selected by the school. Where a small school with a small class was selected for survey then an additional small class from another small school will also be included.

INSTRUMENT DEVELOPMENT

The questionnaire was designed using a web-based professional survey site[47]. The rationale behind the choice of hosting site was that the author had previously constructed and successfully administered a number of other questionnaires using the same site. A range of question types was available including Likert-type, Yes/No, select one from many, select several from many, and open ended. Where the Likert-type was used, the four response option, for example "strongly agree - agree - disagree - strongly disagree", was chosen for this questionnaire. The omission of the neutral "don't know" option was intentional so as to force the students to make a decision, rather than permitting the easy "don't know" option which can become prevalent, especially if questionnaire fatigue sets in towards the end of a survey.

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[47] www.surveyshare.com – owned at the time of conducting the survey by Prof. Curtis J Bonk of Indiana State University.

The survey questions were based on the findings of the literature reviewed in Chapter 2, for example the need to collect data related to the students' gender and ethnic background. As recommended with questionnaires, the first questions were designed to collect demographic data, and the following questions in this case were then based on the first three major research questions of this research, that is to say, the Year 12 students' knowledge of engineering; their attitudes towards engineers and engineering; and the perceived influences on them when considering their career or field of study. In order to focus the students' thinking, the questions were grouped thematically, as shown in Figure 3.1.

Relationship to sample population 1. Gender? 2. School type? 3. Ethnicity? 4. "immigration generation"? 5. Considering engineering as a career or field of study? Knowledge about engineering: To what is the knowledge-base related? 1. Providers of engineering courses? 2. Different types of engineering courses available? 3. Gender ratio of engineers? 4. How engineers contribute to society? 5. Surplus/shortage of engineers in society? 6. International recognition of a New Zealand engineering qualification? How was that knowledge gained? 1. Friend/relative is engineer? 2. Advice from school careers department? 3. School curriculum intervention? 4. Visits to industrial sites? 5. Visits to school by industrialists? 6. Visits to school by science/engineering academics? 7. Publicity through media? 8. Personal research?	Career expectations of careers in general: 1. Interesting work 2. Salary 3. Status 4. Computer-usage 5. Job-mobility 6. Continuous employment? Career expectations of a career in engineering: 1. Interesting work? 2. Salary? 3. Status? 4. Computer-usage? 5. Job-mobility? 6. Continuous employment? 7. Appropriate for women/men? The influences on the pupils' attitudes and expectations? 1. Family 2. Other relatives 3. Friends/peers 4. Mentors 5. Role models 6. Teachers 7. Career advice 8. Media 9. Personal research

Figure 3.1: The question groups which support the main research questions.

No attempt was made to determine the respondents' consistency or truthfulness, by distributing throughout the questionnaire questions which asked for similar or opposing information but used variations in phraseology. The grouping of questions was deliberately overt in an effort to focus the respondents' attention on the survey topics, and hopefully maximize their recall. A total of 60 questions was included in the draft questionnaire (version 1); the topics to be addressed and the stems of the questions are shown as Figure 3.2.

Question Stems for Career in Engineering Questionnaire
Robert Craig, Doctoral Student: 14256680, Curtin University

Please tell us a little about yourself
1) Indicate whether you are male or female
2) Indicate the type of school where you study
3) Please indicate your ethnic background
4) What generation are YOU in terms of arrival in New Zealand?
5) How much education have you experienced in New Zealand?
6) Are you considering engineering as a possible career or field of study?
7) Do you feel the subjects you are studying at school are essentially arts or science?

Now tell us your knowledge of engineering
8) An engineering career could involve significant travel
9) What do you think is the ratio of males to females working in engineering?
10) Where/how can engineering be studied?
11) Is there just one type of engineer, or are there many types?
12) How much do you feel engineers contribute to the way society develops?
13) Do you think New Zealand needs more engineers?
14) Which of the following best describes what engineering graduates do at work?
15) Do you think New Zealand engineering qualifications are recognized abroad?

Now tell us how your knowledge about engineering was gained

16) How many engineers do you know well?

17) Do you have an engineer in your immediate family (parent, sibling)?

18) Do you have an engineer as a close relative (uncle, aunt, 1st cousin)?

19) Have you attended any public seminars/talks on engineering as a career?

20) Have you read any publications on engineering as a career?

21) Was engineering discussed with you as part of school career advice?

22) Have you been on any official visits to engineering/industry sites?

23) Have you attended talks at your school by engineers/industrialists?

24) Have you attended talks your school by engineering lecturers?

25) Does your school offer any engineering subjects (not including woodwork or metal work)?

26) Is your school part of a planned engineering intervention scheme?

27) Are you aware of publicity promoting engineering as a career or field of study?

28) Have you personally researched into engineering as a career or field of study?

29) Who is the MOST important person with whom you DISCUSSED a possible career in engineering?

30) Who is the MOST important person who suggested you FOLLOW a career in engineering?

Please indicate your feelings on the following statements about your future career whatever that might be

31) I expect a high salary from my career

32) I expect high status from my career

33) I hope to use computers frequently at work

34) I expect essentially continuous employment

35) I expect to be able to work internationally

36) I expect my job to help my country

37) It is important to have interesting colleagues

38) it is important to work as part of a team

39) I must find my work interesting

How do you feel about the following statements on engineering as a career?

40) Engineers are well paid

41) Engineers are highly thought of in society

42) Engineers often use computers at work

43) Engineers are in high employment demand

44) Engineers are needed all over New Zealand

45) Engineers make things that help daily life

46) Engineers will help New Zealand develop

47) Engineers have power and influence

48) Engineers are happy at work

49) Engineering should be an interesting career

50) Engineering requires better mathematics and physics than I am capable of

51) Engineering as a career is likely to appeal to? (responses relate to males and females)

Finally please indicate how you feel the following have influenced your ATTITUDE towards engineering as a career or field of study.

52) immediate family

53) other relatives

54) friends

55) mentors

56) television

57) cinema

58) magazines

59) shopping for electronics

60) personal research

Figure 3.2: Year12 career choice questions as basis for peer review draft questionnaire.

Prior to its use with the target population the draft questionnaire was screened in two stages. First, the Version 1 draft questionnaire underwent a peer review by academics who were considered to have knowledge and experience of academic surveys, and an engineering manager who may have an educated but non-academic opinion. Version 2 of the draft questionnaire, with modifications based on the peer review was then subjected to a walk-through[48] of the questionnaire, by students of similar profile to those of the New Zealand population to be sampled. To undertake these testing procedures hard copies of the questionnaire were used.

[48] A walk-through refers to a rehearsal and discussion of some process, in this case the careers questionnaire.

Peer Review

A peer review is used to establish face validity and was conducted on Version 1 of the draft questionnaire. The draft questionnaire was given to the peer review panel, as was a draft of the information sheet to be made available to the students and staff of the participating institutions, and a copy of the research questions.

Table 3.3: Characteristics of the Peer Review Panel

#	Gender	Reviewer experience/expertise
1.	Male	Tertiary educator, MA Linguistics, Sultanate of Oman
2.	Male	Tertiary educator, PhD Computer Science, New Zealand
3.	Female	Tertiary educator, MA Linguistics, Sultanate of Oman
4.	Female	Professional researcher, MA Economics, England
5.	Female	Tertiary Educator, PhD, Australia
6.	Male	Engineering manager, B.E., Sultanate of Oman

The review panel was asked to put themselves in the place of a school leaver, and to review each question of the questionnaire within that context and that of the study's research questions. The panel was requested to screen for ambiguities, inconsistency of format, spelling, repetition of meaning, ease of understanding, perceived usefulness of the questions, the ability of the questionnaire to elicit data relating to the knowledge and attitudes of school leavers regarding engineers and engineering, and to comment on the length of the questionnaire.

In general the panel considered the questionnaire to be well laid out and comprehensive in relation to the research questions. A number of substantive comments were made about the questions, and a summary of these is reported in Table 3.4 together with the actions taken to address them. The panel also identified spelling mistakes and grammatical errors, formatting irregularities, and ambiguities in phraseology, all of which were amended as necessary by the researcher but not reported in Table 3.4.

Table 3.4: Summary of Findings from the Peer Review Panel

Reviewer	Specific Comments by Panel	Action by researcher
1	Q3 Arab not an ethnic group	Q3 Arabic option removed
	Q26 will 'intervention' be understood	Q26 reword
	Questionnaire seems a bit long	Other peers disagree, no action taken
	Embolden sub-heading font	Agree this is useful and so done
	Time taken: not reported	
2	Q3 Arabic not appropriate	Q3 Arabic option removed
	Q5 Not sure if this will be understood	Q5 reword
	Q31 – Q50 should include 'don't know'	Q31-Q50 disagree, no change
	Q52 'immediate family' is ambiguous	Q52 reword
	Q55 'mentor' may need explaining	Q55 reword
	Time taken: less than 15 minutes	
3	Q5 confusing	Q5 reword
	Q7 choice seems missing	Q7 true, option added
	Q10 instruct to 'check' more than one	Q10 reword
	Q28 is this question needed?	Q28 yes, no change
	Q55 what is a mentor	Q55 reword
	Time taken: about 10 minutes	
4	Q5 'only' makes this seem odd	Q5 reword
	Q14 does this need more options?	Q14 include one more option
	Q17 will sibling be understood	Q17 reword
	Q29/30 n/a to some respondents	Q28 regroup some Qs, offer 'skip'
	Q58 include news and magazines	Q58 agreed, include other inputs
	Time taken: "quick and easy"	
5	Q7 spare radio button	Q7 true, option added
	Q14 expand to gather more information	Q14 include one more option
	Q17 is 'sibling' well understood?	Q17 reword
	Q46 what is meant by development	Q46 reword
	Q52 'your attitude' relates to what?	Q52 reword
	Time taken: not reported	
6	Q7 unused radio button	Q7 true, option added
	boredom so many engineering Qs?	regroup some Qs and offer 'skip'
	Time taken: about 10 minutes	

Version 1 of the draft questionnaire was modified as indicated in the right hand column of Table 3.4 labeled "Action by researcher", after which Version 2 was then printed ready for the walk-through.

The Walk-Through

The clarity and meaningfulness of the peer reviewed questionnaire was further tested with a face-to-face walk-through conducted in focus group fashion with students from an international school in the Sultanate of Oman. The Principal of the school was visited by the researcher prior to the walk-through, and supplied with the hard copy of the questionnaire, the draft survey information sheet, and the draft letter for the New Zealand school Principals. Based on the information supplied, the Principal then permitted his students to read the questionnaire and to take part in the walk-through process.

The Walk-Through Process

The distribution, discussion, and researcher response process described in Table 3.5 was adopted in order to maximize the effectiveness of the walk-through, in terms of accuracy of the feedback from the students, and the discussion time made available by the school Principal.

Table 3.5: The Walk-Through Process for the Muscat School Students

Activity	Rationale
1. The Y12/Y13 equivalent students were individually given hard copies of the questionnaire a day prior to the walk-through and asked to go through it without discussing it with each other: making notes on the hard copy as they wished.	1a. Time during the walk-through would be devoted to discussion and not to reading the questionnaire. 1b. A record of their initial thoughts was maintained. 1c. The chances of alternate ideas being aired were improved. 1d. The questionnaire completion time could be gauged.

2.	The question items were then discussed by the students and the author (the walk-through interview) to check for interpretation, clarity, and ambiguity.	2a.	Items can be adjusted to achieve the desired meaning in a clear and unambiguous manner.
3.	Items adjusted by the author in the presence of the student group.	3a.	No need to repeat the walk-through process.
4.	The research in general was discussed to see if other/better items might be included in the questionnaire.	4a.	The students' perspective may well be different to the author's/researchers'.

The Walk-Through Interview

The walk-through of the questionnaire was conducted with six students from a private school in Muscat, The Sultanate of Oman, on March 1st 2009. The focus group included three females and three males of age equivalent to Year 12 and Year 13 in New Zealand. Four of the students were from the science stream and two from arts, with two pursuing arts-based careers, two pursuing science-based careers, and the other two undecided at the time. All were fluent in English. The students proved to be mature and committed, their feedback was useful and adjustments to the questionnaire were made as believed appropriate by the researcher.

The Table 3.6 indicates the comments from the school students and the adjustments, if any, made to the questionnaire. Only those questions from the Version 2 of the draft questionnaire with which the students had issues have been recorded.

Table 3.6: Comments and Actions Resulting from the Questionnaire Walk-Through

Q#	Synopsis of students' comments	Author's comments	Action taken
5	What will be understood by the word "some"	My intention was to assess whether a lot or a little time had been spent at the two levels.	Change "some" to "a little"
8	All four students had trouble trying to work out the meaning of this question	On reflection I'm not sure if this Q is useful as many careers involve travel these days	Delete this question
9	One student wasn't sure if this applied globally and wasn't sure if a guess was okay.	This is aimed at NZ and I expect the students to guess.	Reword to include "guess" and NZ
11	"Followed" found to be ambiguous, "variety" could be just 2 options	Reword to clarify	Followed > studied Variety > wide variety
12	The students were unsure as to whether this referred to physical or social development	I feel it's fairly overt that engineers are involved with structural development so this is aimed at the social/psychological change.	Reword to: "society as a whole develops"
19	Public seminars could be delivered in school so this may duplicate Q23	This is meant to be outside school, not in school	Include the words "outside school"
24	The students pointed out that maths (physics and chemistry) are part of engineering	I was really trying to see if the science promotion was happening	Delete this question as it will be covered by Q25
25	The students had no idea of this and that may be the case in NZ	This promotion by IPENZ may cause a bias to the results so needs to be known	Promote this to Q1 indicating that the administrator should inform the students
28	This assumes a discussion about engineering has taken place, also "important" caused concern	Agreed, so must make more inclusive	Reword completely
29	As above	As above	As above
30-35	Some confusion between "expect" and "want"	I mean "expect" as the students should speculate about their future possible career	Put the verbs in bold so as to accentuate their importance
39-50	The non-engineering students felt these questions irrelevant	These are to compare with Qs 30-38	Include "even if your field will not be engineering" at the introduction to Q39

Q#	Synopsis of students' comments	Author's comments	Action taken
46	Power over who/what?	This is meant to reflect the status of engineers	Reword as "have high status in NZ society"
47	The students were not sure about the meaning	This Q won't reveal anything that couldn't be applied to any other profession	Delete question
50	One student was unsure of this Q	Essentially okay	Reword to include "do you feel that ..."
51-60	This series of questions assumes some consideration of engineering by all.	This is not quite correct so should give an "opt out of the series" option	"opt out" instruction inserted
??	No question regarding alternate fields of study	This was previously included but somehow omitted	Include question on likely field of study

After the walk-through was completed, the Version 2 questionnaire was revised by incorporating the changes indicated in Table 3.6 in the "Action taken" column, and an electronic version of the final questionnaire created using the SurveyShare Web site. A copy of the entire electronic version, including the opening page login and subsequent questionnaire, is included as Appendix C.

The opening screen of the questionnaire consisted of the research title, an indication of the time required to respond to the questions, and a reminder to the students of their right to withdraw from the survey at any time. The questions which followed established the respondent's relationship to the population sample in terms of school type and governing authority, their gender, arrival in New Zealand, schooling in New Zealand, academic stream, and ethnicity. The screen-pages thereafter contained questions grouped by the major question topics, that is to say, knowledge of engineering and how that knowledge was gained, general career expectations and engineering career expectations, attitude towards engineering as a career, and the source(s) of those influences on attitudes and expectations. The respondents were also asked to indicate the career or field of study they would like to follow.

Questions within a group were tagged with identifiers which permit easy recognition of the context of the question groups, for example, Pers1, Pers2, and Pers3, are the tags for the first three questions relating to personal information such as gender and ethnicity. These tags are decoded by some statistical software and associated with the data returned. Essentially the tags make the raw data more meaningful to a reader, and easier to talk about during a presentation.

Web-based Pilot

Final testing for access and ease-of-use of the online, web-based, version of the questionnaire occurred in two stages prior to release for this research. Firstly, a url and password were distributed to the research supervisory team and some of the academics involved in the peer review. No difficulties in accessing or completing the questionnaire were reported, and data entry into the database and the retrieval of information was achieved as expected. Secondly, the teachers of the participating schools were set up with a dummy questionnaire, identical to the students' questionnaire, and encouraged to test it for suitability and accessibility. One teacher reported that the site was 'electronically perceived' as a social network or advertising site and hence blocked by the school's firewall. This technical issue proved too much of an obstacle to overcome at the school level even though the teacher was happy for her students to have been involved.

INSTRUMENT ADMINISTRATION

A multi-faceted strategy inviting participation in the research was designed, in order to maximize the chance that the schools' Principals and/or careers advisors would give permission for their students to participate in the survey:

1. The letters to the school Principals and/or careers advisors were emailed explaining the rational, content and benefit of the research (Appendix A).

2. A dummy questionnaire, identical to the version to be completed by the students, was created so that the schools' officers could see what their students would be answering, and to test the schools' accessibility to the survey site.

3. The author has an association with IPENZ through a previous colleague, and prior correspondence with IPENZ indicated a willingness to assist with the schools' engagement with this research. IPENZ agreed to notify their consultants who work with schools to mention the existence and benefits of the research, in the hope that the school Principals would agree to permit their students to take part.

4. A friend and research colleague, Dr. Kay Hawk, works with many schools throughout Auckland and consequently has an established relationship with many of the school Principals. Dr. Hawk agreed to contact those schools with which she had an association, in order to request that their students be permitted to participate in the survey.

In February of 2010, the beginning of the New Zealand academic year, 32 schools from within the Greater Auckland region were selected to take part in the survey. The selection of the schools was achieved through the use of a random number generator and the school list available on the New Zealand MOE statistics site *Education Counts*. The school list was divided into the six strata, and in order to retain the schools' anonymity, the list was reordered and each school allocated a code number. The schools were then selected from within their stratum based on their code and with the use to the random number generator. The selection of schools to be included in each stratum continued one at a time, until the expected number of respondents equalled or exceeded the number required for that stratum.

The email addresses of the Principals and/or careers advisors were gleaned from school Web sites, the information letter and access password were then dispatched to them by email, and the dummy questionnaire activated. Simultaneously the list of selected schools was distributed to the supervisors of this research as well as to IPENZ, and Dr. Hawk.

The schools where the Principal had agreed to take part were sent the url of the questionnaire, a repeat of the instructions for student selection and supervision, and their school code. The purpose of including the school code was to act as an incentive for the schools to take part; it enabled the author to return to the schools their own data for their own use. All of the schools which took part indicated their school number, and all schools had their data returned with their school number acting as a password for security. Not only did the code act as first line security to stop the returned file being opened by unauthorized personnel, it also acted as second line security in case a school was mistakenly sent the data from another school.

When a school Principal declined to permit their students to take part in the research, that school was replaced by another school or schools selected at random from the same stratum, until sufficient expected responses were once more achieved.

It was anticipated that the response rate should be relatively high as the questionnaire was to be supervised by a member of the school staff, within school grounds. Additional techniques, such as follow-up telephone calls to individual school Principals or careers advisors, were to be employed to encourage them to ensure completion of the survey at their school.

The survey remained open for approximately five months, from the beginning of May 2010 to the end of September 2010, so that schools could time-table the questionnaire access for their students in the most flexible and convenient manner.

The School Students' Responses

The strategy of multiple approaches to the school Principals and/or careers advisors initially seemed to have the desired effect, with some 250 returns being pledged by a number of schools during the first few days after activating the questionnaire. It was also immediately noticeable that the state co-education sector was by far the most responsive to the survey. This was the sector in which school Principals had been contacted by Dr. Hawk.

Follow-up calls to the schools were made from Oman by the author on a number of occasions in order to try to sustain interest. However, despite pledges to take part, the minimum number of returns for each stratum was not met. The survey was closed despite the shortage of responses as (a) further follow-up calls could be conceived as verging on harassment, and may have negatively affected a school Principal's approach to taking part in further surveys, and (b) restarting with new schools would have delayed progress of the research without any guarantee that the additional schools contacted would actually take part.

A spreadsheet recording the school codes, the randomly selected schools, the number of students available in Year 12, the school contact information, and the interaction between the author and the school, is retained by the author to maintain confidentiality. Table 3.7 depicts the response of the schools, as represented by their school codes, across the educational sectors. A total of 292 questionnaires was completed, of which 261 were from the state co-education sector.

Table 3.7: Report on the Responses by Greater Auckland School Students to the Careers Survey

School authority	Year 12 Population Size	Stratum Sample size	Schools selected	Agreed to participate	Expected responses	Minimum required	Obtained responses
State funded sector Co-Ed	12,334		School 1		30		
			School 2	yes	30		40
			School 3		30		
			School 4		30		
			School 5		30		
			School 6		14		
			School 7	yes	30		41
			School 8		30		
			School 9	yes	30		27
			School 10		30		
			School 11	yes	30		0
			School 12		30		
			School 13		30		
			School 14	yes	30		31
			School 15		30		
			School 16	yes	30		103
			School 17		30		
			School 18		4		
			School 19	yes	30		19
			School 20		30		
		545			558	257	261
State funded sector Male	1,898		School 1	yes	30		14
			School 2	yes	30		0
			School 3		30		
		84			90	40	14
State funded sector Female	2,120		School 1		30		
			School 2	yes	30		13
			School 3	yes	30		0
			School 4		30		
		93			120	44	13
Partly Privately Funded Sector							
Co-Ed	1,299		School 1		30		
			School 2		30		
		57			60	27	0
Male	54		School 1	yes	30		3
		3			30	1	0
Female	376		School 1	yes	30		0
		18			30	8	3
Totals	13,413	800			888	377	292

Notes.

1. The headings of the table relate to the following:
   School Authority – whether the schools are publically or partially privately funded
   Year 12 population size – the number of Year 12 students in the stratum
   Stratum sample size – the number of Year 12 students to be sampled from the stratum as per the calculations from Table 3.2
   Schools selected – the schools which were selected and then contacted
   Agreed to participate – those schools which agreed to take part
   Expected responses – for schools with more than 30 students, a single class size of 30 students was the expected response.
   Minimum required – the number of completed questionnaires required for the stratum.
   Obtained responses – the number of questionnaires completed from a school

2. The total number of returns, 888, results from selecting schools within stratum one at a time until the required number for that stratum is either equalled or exceeded.

The database output from surveyshare.com was returned to the researcher in a number of formats including *by respondent by question*, as *aggregated responses*, and in a numerical format suitable for input to a range of statistical programs, in this case for SPSS[49]. The questions had been labeled with generic grouping names for ease of identification. In this case the first three personal data questions were labeled Pers1, Pers2, and Pers3, and it was obvious from an initial scan of the data that this strategy was going to make the identification of related data, and any subsequent discussion and presentation, much more meaningful.

Summary of instrument administration

To recapitulate, the sampling method used for this research was stratified random sampling. The population of approximately 18,000 Year 12 students required a sample size of 377 in order for the results to be generalized to the Year 12 Greater

[49] Statistical Package for the Social Sciences

Auckland population with a 95% level of confidence. The questionnaires were to be distributed across the sample strata in proportions which reflected the ratio of strata population to total population. Those numbers were then approximately doubled to compensate for the expected 50% return rate.

Online surveying of schools from a distance (the author was located in the Sultanate of Oman) proved problematic despite the possible benefits of this work. Although the Principals of 13 of the 32 selected schools agreed to their students taking part, only students from 9 schools actually did so. The best response rates came from students of schools that were contacted by a New Zealand colleague, Dr. Hawk, who was known to them. It can be seen from the matrix of Table 3.7 that 261 questionnaires were completed and returned from the State Co-Education sector. Unfortunately, very few questionnaires were completed in the other sectors.

In addition to the difficulties of achieving the desired number of responses, one school completed 103 instead of the expected 30 sets of questionnaires. The author contacted the school Principal to ensure that these were genuine responses. It transpired that the Principal was very enthusiastic about the study and immediately rotated all the Year 12 students through the process. There was concern that the large input from this school may bias the overall results, and so the returns from this school and the other schools were analyzed separately to look for unusual traits in the respondents' general demographics. No significant differences were detected and so the results from all schools were combined.

OVERVIEW OF THE DATA ANALYSIS

These research data are quantitative and hence inferential statistical analysis will be employed in order to determine trends of the data. The files returned from surveyshare.com were in a variety of formats including aggregate/by respondent/by question, and a numerically coded version for use with statistical packages such as SPSS. The file returned for use with SPSS required a few adjustments in order to make it more useable and more intuitive for presentation. The Likert-type responses were enumerated: strongly agree=4, agree=3, disagree=2, strongly disagree=1; the Yes/No responses enumerated: Yes=1, No=0.

The valid responses returned by the Year 12 careers survey numbered close to 300 and came from students attending 9 schools from within the Greater Auckland region. The majority, 89.7%, came from the state co-educational sector with just 4.7% from the state boys sector, 4.4% from the state girls sector, and just 0.1% from the private sector.

The gender mix was around 45% female and 55% male, mainly Pākehā, with Māori and Pasifika making up the largest of the minority groups. The majority of the students, 80%, had done their junior and senior schooling in New Zealand, with just 5% having experienced only part of their senior education in New Zealand. Students in both the arts and sciences streams were represented in the sample, and 22% of the students indicated their school was part of a science promotion scheme.

ETHICAL ISSUES

The survey was to be conducted as an online questionnaire, completed anonymously by students over the age of 16 years and administered in school hours and within the school grounds by school staff. As such it was considered a low ethical risk research survey.

Ethical approval (SMEC20080055) for this research was gained through the Ethics Committee of Curtin University by completing HREC-Form C and submitting the research proposal together with the candidates'/Principals' information sheet (see Appendix B) and a copy of the draft questionnaire design (see Appendix C). A separate consent form was not required because the opening page of the questionnaire, reproduced in Appendix C, reminded participants of their right to withdraw from the survey at any stage of the process, but that submitting their responses constituted agreement by the student to the use of their responses in this research.

SUMMARY

This chapter included a discussion of the research design, the target population and sample selection, the development of the data gathering instrument, and the survey administration. The preparation of the data for statistical analysis was also described as were the general demographics of the students who responded, and the process of obtaining ethical approval.

The following chapter analyzes the responses to the survey, looking for data trends and relationships which relate to the first three major questions of this research: the knowledge of, the attitudes towards, and the influences on, Year 12 students when they were considering their careers or fields of study.

CHAPTER 4

SURVEY RESULTS

INTRODUCTION

This chapter reports the results of the online survey of Year 12 school students from the Greater Auckland Region of New Zealand. The survey was designed to collect data to answer the following research questions:

RQ1. What do Year 12 students in Greater Auckland know of careers in engineering?

RQ2. What are the attitudes of Year 12 students in Greater Auckland towards engineering as a career or field of study?

RQ3. What factors do Year 12 students in Greater Auckland perceive have influenced their attitudes towards engineering as a career or field of study?

RQ4. Based on the findings of this research, what are the implications for school advisors, and others advising students on the choice of careers in engineering and related technical fields?

Questions were posed to collect data which would permit the Year 12 sample to be compared with the demographics and data tendencies of samples from other studies conducted in New Zealand or elsewhere in the world. These studies were discussed in the literature review for this research, the analysis of which pointed to possible relationships between a student's propensity to choose a career in engineering or related technologies, along with a variety of factors including gender, confidence with mathematics and physics, and/or their nation's level of industrial development. Appendix E contains a summary of the raw responses data from the survey items.

THE DEMOGRAPHICS OF THE GREATER AUCKLAND SAMPLE

Data were returned by 292 Year 12 students who were attending nine schools within the Greater Auckland region. Table 4.1 provides an overview of the demographic characteristics of the sample as assessed from the students' responses to the survey questions. The survey question numbers are in the left hand column of the table.

Table 4.1: The Demographic Characteristics of the Year 12 Sample

Survey Question	Characteristic	Response Choices							Missing
Q3	Gender	Male	Female						
	n =	157	129						6
	% of sample	54%	44%						2%
Q4	School type	State Co-Ed	State girls	State boys	Pte Co-Ed	Pte girls	Pte boys		
	n =	261	13	15	0	3	0		-
	% of sample	89%	4%	5%	0%	1%	0%		
Q5	Ethnic background	Pākehā	Chinese	Indian	Māori	Other Asian	Pasifika	Other	
	n =	132	15	20	24	19	29	53	-
	% of sample	45%	5%	7%	8%	7%	10%	18%	
Q6	Arrival in New Zealand	Student born overseas	Born NZ Parents born O/S	Parents born in NZ	Long NZ ancestry				
	n =	91	48	91	59				3
	% of sample	31%	16%	31%	20%				1%
Q7	Experience in NZ education	No junior Some senior	No junior Most of senior	Some junior Most of senior	Most of junior Most of senior				
	n =	15	16	36	225				-
	% of sample	5%	5%	12%	77%				
Q8	Subjects Studied	Mainly Arts	Mainly Science	Balance					
	n =	62	116	112					2
	% of sample	21%	40%	38%					1%
Q2	School is part of a science/ engineering promotion	Yes	No	Don't know					
	n =	63	149	73					7
	% of sample	22%	51%	25%					2%

Note. The total number of respondents is 292.

As shown in Table 4.1, 157 of the respondents were male and 129 were female (6 respondents skipped the question). Almost all, 289 of the 292 students, came from publicly funded schools, of which 261 were from the state co-educational sector, 13 from the state girls sector, and 15 from the state boys sector. Just 3 responses came from students attending one school in the private sector. The ethnic distribution of the sample was 45% Pākehā, with Pasifika and Māori being the largest minority groups with 10% and 8% respectively. Of those whom one might consider as new New Zealanders[50], 31% indicated they were born overseas and 16% indicated they were first generation New Zealanders. Most students, about 80%, had done most of their junior and senior schooling in New Zealand, with just 10% experiencing some or most of their senior education in New Zealand while having all their junior education overseas. Students in both the arts and sciences streams were well represented, and 22% indicated their school was part of a science promotion scheme.

Additional information on the students of the sample was retrieved from the New Zealand MOE Web site, and not as part of the questionnaire. The school decile numbers[51] associated with the participating students, indicated that the sample had the following decile ratings associated with the respondents: 43% of the students were from high decile schools (8-10), 45% from medium decile (4-7), and 11% from low decile (1-3). The remaining 1% of the students was from a school in the private sector, for which there is no decile rating.

The length of time that students and their families had lived in New Zealand was expected to exhibit a relationship with ethnicity, and so to gain a more detailed understanding of the characteristics of the survey sample these two factors were cross-tabulated. Table 4.2 shows the results of this analysis.

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[50] Within this research 'new New Zealander' indicates that the student or their parents were immigrants who were born overseas.

[51] Decile number refers to the socio-economic environment of the catchment area from which a school accepts its students (decile 1 = lowest and 10 = highest).

Table 4.2: Relationship between the Students' Ethnic Backgrounds and their New Zealand Ancestry

Survey Question Q5	Ethnic Background	Q6 New Zealand ancestry (%)			
		Born overseas	Born NZ, parents born O/S	Parents born NZ	Long NZ ancestry
	Pākehā (*n* = 131)	14	12	44	31
	Chinese (*n* = 15)	66	20	7	7
	Indian (*n* = 20)	65	35	0	0
	Māori (*n* = 24)	13	0	54	33
	Other Asian (*n* = 19)	79	21	0	0
	Pasifika (*n* = 29)	31	55	14	0

Note. The total number of respondents is 291.

The results of Table 4.2 show a strong relationship between ethnic background and New Zealand ancestry, χ^2 ($df = 9$, $N = 289$) = 106.36, p = 000, with a large effect size for Cohen's *w* of 0.61[52]. The data in Table 4.2 show clearly that 100% of the Indians and "other Asians" from the sample were "new New Zealanders", as were 86% of the Chinese. Given this close association between ethnicity and New Zealand ancestry, only one of the factors, ethnicity, will be dealt with in the subsequent data analyses of this research.

In the following sections of this chapter the findings related to each of the research questions are presented. As many of the variables have a small amount of missing data (usually less than four responses), percentage results in the tables are reported in terms of valid responses (due to rounding, some percentages may not total exactly 100). Where there is a larger amount of missing data, attention is drawn to this issue.

[52] Cohen's *w* is used as an effect size for the Chi-square test, and Cohen suggested that effect sizes of *w* = 0.01 indicate a small effect size, 0.30 a medium effect, and 0.50 a large effect.

RQ1. WHAT DO YEAR 12 STUDENTS IN GREATER AUCKLAND KNOW OF CAREERS IN ENGINEERING?

Assessment of the Students' Knowledge of Engineering

The students' knowledge of engineering careers was assessed through questions Q9 to Q15, which described ideas and information that a senior school leaver could be expected to know, or expected to have formed an impression about. Table 4.3 shows the ideas about engineering which were the basis for the knowledge survey questions, and the percentage of the responses to each question.

Table 4.3: Students' Knowledge about Engineering

Survey Question	The notions of the survey questions	Response choices (%)			
Q9	Ratio males to females in engineering M:F (*n* = 288)	80:20	60:40	40:60	20:80
		56	35	5	4
Q10*	Where engineering programs are available (*n* = 292)	Unis	Other institutions	Online	Part Time
		86	74	28	44
Q11	Types of engineering programs available (*n* = 287)	All the same	Mech Elec Civil	Variety of fields	Graduate, post-grad
		8	23	34	35
Q12	The extent to which engineers contribute to society (*n* = 289)	Not a lot	A little	Quite a lot	Enormously
		3	11	57	29
Q13	New Zealand needs more engineers (*n* = 291)	Yes	No	No idea	
		51	8	41	
Q14	The type of work done by engineers (*n* = 289)	Engine Repair	Design things	Driver, vehicles	Appliance repair
		20	71	3	6
Q15	New Zealand engineering qualifications are recognized overseas (*n* = 289)	Yes	No	Don't know	
		51	16	33	

* Students were invited to check more than one option, hence the total exceeds100%

The questions were divided broadly as "academic" and "societal". The academic questions related to where and in what study modes engineering might be studied (Q10), the broad fields of study and at what academic level (Q11), what engineers do at work (Q14) and the international currency of the qualification (Q15). The societal questions focused on gender ratios within engineering (Q9), engineers' contribution towards society's development (Q12), and the demand for engineers in New Zealand (Q13).

The data related to Q9 in Table 4.3 indicate the sample had considered engineering to be male dominated, in that 91% of the students felt that at least 60% of engineers were male. Most students, around 80%, were aware that engineering was offered at universities and other institutions (Q10), but less than half were aware of online or part-time programs. In terms of Q11, only 8% of students thought all engineering programs were the same, and about 70% understood a variety of engineering fields exist. The responses to Q12, a more societal question, show 86% of the sample held the opinion that engineers contribute at least quite a lot to society's development, yet although more than 50% thought New Zealand needed more engineers (Q13), 41% had no idea about demand. Some students were rather confused about the kind of work done by engineers (Q14), with 20% thinking they made mechanical repairs, and only 71% recognizing the design role in engineering. Finally, for these questions on the students' knowledge of engineering, the responses to Q15 revealed that only one half of the students (51%) knew that New Zealand engineering qualifications were internationally recognized.

The responses in Table 4.3 suggest the students had a reasonable level of general knowledge about engineering, the kind of work done by engineers, and some idea of their training.

Three results however stand out in Table 4.3 as requiring further investigation: the responses to the questions on the gender ratio within the engineering fraternity (Q9), the extent to which engineers were perceived to contribute to society (Q12), and the demand for engineers in New Zealand (Q13). Given that these factors have the potential to motivate (or de-motivate) males and females differently, it was decided to explore how males and females had responded to these questions. The results of this analysis are shown in Table 4.4.

Table 4.4: Males' and Females' Knowledge about Engineers and Engineering

Survey Question	Knowledge about engineering	Students	Response choices (%)			
			80:20	60:40	40:60	20:80
Q9	Ratio of males to females in engineering	Male (n = 155)	55	36	6	3
		Female (n = 127)	59	33	3	5
			Not a lot	A little	Quite a lot	Enorm-ously
Q12	Extent by which engineers contribute to society	Male (n = 155)	3	12	56	30
		Female (n = 128)	2	12	60	26
			Yes	No	No Idea	
Q13	New Zealand needs more engineers	Male (n = 156)	55	10	36	
		Female (n = 129)	47	6	47	

The data of Table 4.4 show little difference between male and female perceptions on these issues and a Chi-square analysis confirmed there was no statistically significant association. Although male students seemed to know more about the demand for engineers in New Zealand (Q13), the difference was not statistically significant, χ^2 (df = 2, N=285) = 4.13, p = .127.

The Sources of the Students' Knowledge of Engineering

The sources of the students' knowledge were approached through questions Q16 to Q25. The familiarity and frequency of exposure to engineering-related input was gauged through Q16, and the origins of the students' knowledge were addressed though survey questions Q17 to Q25. Unofficial channels of information, such as family, friends, public seminars, the media, personal research, and other ad hoc opportunities to gain knowledge about engineering, were the subject of questions

Q17 to Q20, and questions Q24 and Q25. More official channels, such as school careers advice and visits to or from people from industry, were covered by questions Q21, Q22, and Q23. Table 4.5 shows the suggested sources of knowledge regarding engineering, and the frequencies of the students' responses to each question.

Table 4.5: The Sources of the Students' Knowledge about Engineering

Survey Questions	Question Content	Response choices (%) None	1-4	5-10	>10
Q16	How many engineers do you know well? (*n* = 291)	40	47	8	5
			Yes	No	
Q17	Do you have engineers as: immediate family? (*n* = 292)		20	80	
Q18	other relatives? (*n* = 292)		42	58	
Q19	Have you: attended public seminars outside school? (*n* = 292)		15	85	
Q20	read publications on engineering? (*n* = 292)		29	71	
Q21	discussed engineering with careers advisor? (*n* = 292)		38	62	
Q22	officially visited engineering/industrial sites? (*n* = 292)		18	82	
Q23	attended talks at your school by engineers and/or industrialists? (*n* = 292)		11	89	
Q24	been aware of publicity promoting engineering? (*n* = 292)		33	67	
Q25	personally researched into engineering? (*n* = 292)		27	73	

The data for Q16 in Table 4.5 indicate that not many of the students knew engineers well, in that 40% reported they knew none at all and another 47% knew four or less. The responses to questions Q17 and Q18 indicated only 20% have an engineer in their immediate family although 42% reported that they did have an engineer as a relative. The responses to the questions which could be described as unofficial education about engineering (Q19, Q20, Q24, Q25) suggested that most students had received little input from these sources. Less than 20% had attended public seminars

(Q19), and less than one third recalled reading publications about engineering (Q20), other publicity (Q24) or personal research (Q25). The greatest source of knowledge was indicated as the result school careers advice (Q21), where 38% reported a discussion on engineering. Conversely however, it appears visits to industry (Q22), or in schools by industrialists (Q23), were either rare or unpopular.

In summary, the responses to the survey questions related to RQ1 suggest that the students had a reasonable general knowledge about engineering and some of the related issues. Of the knowledge about engineering which might have been perceived differently by males and females, it transpired that their response patterns were very similar. On the subject of where the students' knowledge came from, the data indicate that some students had engineers as family or immediate relatives, as yet in this report their contribution to the students' knowledge is unknown. However, of the other suggested sources, none seemed to have contributed much to the students' knowledge. Most students had not had the opportunity or had chosen not to avail themselves of the opportunity, to gain knowledge about engineering, apart possibly from school careers advisors.

RQ2. WHAT ARE THE ATTITUDES OF YEAR 12 STUDENTS IN GREATER AUCKLAND TOWARDS ENGINEERING AS A CAREER OR FIELD OF STUDY?

The survey questions related to RQ2, attitudes towards engineering as a career or field of study, span questions Q26 to Q46 inclusive. The initial series of questions, Q26 to Q34, probed the students' hopes and expectations for their future careers, whatever those careers might be, creating a context-free impression of the sample's attitudes towards careers in general. Question Q35 asked in a direct manner if the students were considering engineering as a career or program of study, and questions Q36 to Q46 were similar to questions Q26 to Q34, but this time addressed the students' attitudes specifically towards the notion of a career in engineering. The students were asked to respond to all of questions Q26 to Q46 even if they were not considering engineering as a career or field of study.

Assessing the Students' Attitudes towards Engineering as a Career

This section starts with the responses to Q35: Are you considering engineering as a career or field of study? Although these responses are being reported out of sequence with respect to the series of questions in the questionnaire, presenting the data of Q35 at this stage suits the flow of the reporting of the questionnaire results as a whole because it provides context of the students' choices for a career in the field of engineering. The students' responses for Q35 are recorded in Table 4.6.

Table 4.6: Students' Responses about Considering a Career in Engineering

Survey Question	Question content	Response choices (%)		
		Yes	Maybe	Not at all
Q35	Are you considering engineering as a career or field of study? (n = 283)	13	40	47

The data of Table 4.6 indicate that only 13% of the sample were actively considering the possibility of engineering for their future career or field of study, but that nearly half (47%) had already decided against engineering as a career option.

In the previous section of this chapter the suggested sources of the students' knowledge about engineering were discussed, so it is now possible to explore relationships between the students' decisions to follow engineering as a career and those suggested sources of knowledge. That is to say, did some sources appear to have a stronger relationship than others on the students' career choices. The following series of tables, Table 4.7 to Table 4.9, contain data which show the relationships between the various sources of student knowledge about engineering, and their responses to whether or not they were considering a future in engineering.

Table 4.7 shows the relationships between the number of engineers who the students knew well and whether they were considering a future in engineering. Two of the categories (5-10 and >10 engineers known well) of sources of knowledge previously reported in Table 4.5 contain small amounts of data. It seemed sensible to combine the responses from these two categories into one category and label it as “5 or more” so that greater meaning can be attached to the analysis.

Table 4.7: Relationship between the Number of Engineers the Students Knew Well, and whether the Students were Considering Engineering as a Career

Survey Question	Question Content		Q35 Are you considering engineering as a career or field of study? Response choices (%) Yes	Maybe	No
Q16	How many engineers do you know well	None (*n*=117)	5	43	52
		1-4 (*n*=135)	15	39	47
		5 or more (*n*=37)	32	41	27

The responses to Q16 in Table 4.7 showed two trends in opposing directions. There appeared to be increased interest in an engineering career with an increase in the number of engineers that the respondents knew well, and conversely, reduced numbers of students rejecting engineering with an increase in engineers that they knew well. These relationships are statistically significant with χ^2 ($df = 4$, N=289) = 20.58, $p = .000$, and a small effect size for Cohen's $w = 0.27$.

The following table, Table 4.8, shows the students’ responses as to whether or not they were considering a future in engineering, distributed by whether they had engineers as immediate family or other relatives.

Table 4.8: Relationships between Engineers in the Students' Family and whether the Students are Considering Engineering as a Career

Survey Question	Family members who are engineers		Q35 Are you considering engineering as a career or field of study? Response choices (%) Yes	Maybe	No	$\chi 2$	*p*
Q17	Do you have a parent, brother or sister who is an engineer?	Yes (n=60)	27	33	40	12.14	.002
		No (n=229)	10	42	48		
Q18	Do you have any other relative who is an engineer?	Yes (n=124)	17	43	40	5.96	.051
		No (n=165)	10	39	51		

Note. *df* = 2, *N* = 289.

In relation to having or not having relatives as engineers, of those students who had engineers as immediate family, nearly three times as many were considering engineering compared with those students who did not. This relationship is shown to be significant with χ^2 (df = 2, N=289) = 12.14, p = .002 and a small effect size using Cohen's w of 0.20. For those who had engineers as 'other relatives', nearly twice as many were considering engineering as compared with those who did not. However, given the confidence level of 5% used in this analysis and the small effect size, further investigation of these results seems unwarranted.

Finally for this section which is exploring the relationships between the sources of the students' knowledge about engineering and their choices of a career in engineering, Table 4.9 shows the students' responses regarding career choice distributed across a number of other possible sources of knowledge.

Table 4.9: Relationship between Other Sources of Knowledge and Students Considering Engineering

Survey Question	Suggested sources of knowledge about engineering		Q35 Are you considering engineering as a career or field of study? Response choices (%) Yes	Maybe	No	$\chi 2$	p
Q19	Have you attended public seminars/talks outside school on engineering?	Yes (n=45) No (n=244)	34 9	41 41	25 50	22.42	.000
Q20	Have you read publications on engineering as a career?	Yes (n=85) No (n=204)	32 5	55 34	13 61	67.28	.000
Q21	Was engineering discussed with you as part of school careers advice?	Yes (n=110) No (n=179)	25 6	47 36	28 58	32.23	.000
Q22	Have you attended official visits to industrial sites?	Yes (n=53) No (n=236)	27 10	45 39	28 51	13.62	.001
Q23	Have you attended talks at school by engineers and/or industrialists?	Yes (n=32) No (n=257)	44 9	34 41	22 50	30.61	.000
Q24	Are you aware of publicity promoting engineering?	Yes (n=95) No (n=194)	25 7	46 38	29 55	26.81	.000
Q25	Have you personally done research into engineering?	Yes (n=78) No (n=211)	37 4	51 37	12 59	77.96	.000

Note. $df = 2$, $N = 289$

The analysis of the responses to questions Q19 to Q25 indicates that in all cases, larger numbers of students who answered 'yes' to each potential source of information, were also considering engineering as a career. The opposite was true for those who answered 'no' to those same questions, in that far more of the students who answered 'no' had also rejected engineering as a possible career. The relationships between these data are also statistically significant in each case; however, given the questions and methodology used to elicit these data, it is impossible to ascertain cause and effect.

Next, the series of questions which canvassed the students' attitudes towards careers in general are considered. Table 4.10 contains questions Q26 to Q34 and the frequencies of students' response choices to those questions.

Table 4.10: Students' General Attitudes towards their Perceived Future Careers

Survey Question	Question content	Response choices (%) strongly disagree	disagree	agree	strongly agree
Q26	I expect a high salary from my career (*n* =288)	1	14	61	24
Q27	I expect high status from my career (*n* =290)	3	22	59	16
Q28	I expect relatively continuous employment (*n* =289)	2	10	63	25
Q29	I expect to be able to work internationally (*n* =290)	1	14	59	26
Q30	I expect my job to help my country (*n* =288)	4	24	50	23
Q31	I hope to use computers frequently at work (*n* =289)	6	26	48	20
Q32	It is important to have interesting colleagues (*n* =289)	2	10	62	26
Q33	It is important to work as part of a team (*n* =289)	2	10	46	42
Q34	I must find my work interesting (*n* =291)	1	4	32	63

The general career expectations of the sample seemed optimistic in that the students mainly responded to the positive attributes of employment. Around 75% expected high status (Q27) and to do work which will help their country (Q30), and 85% expected a high salary (Q26). There was agreement by around 90% of the sample to the questions on expecting relatively continuous employment (Q28), opportunities for overseas work (Q29), the importance of having interesting colleagues (Q32), working in a team environment (Q33), and having interesting work (Q34). More than two thirds of the sample, 69%, were in agreement with the statement of question Q31, "I hope to use computers frequently at work".

The students' attitudes towards a possible career in engineering were assessed by questions Q36 to Q45, using notions which were similar to those related to their attitudes towards careers in general, Q26 to Q34. Table 4.11 shows the questions to which the students' attitudes towards engineers and engineering were sought, and the percentage frequencies of their responses.

Table 4.11: Students' Attitude towards Engineers and a Possible Career in Engineering

Survey Questions	Question content	Response choices (%) strongly disagree	disagree	agree	strongly agree
Q36	Engineers – are well paid (*n* =291)	4	12	68	16
Q37	are highly thought of in society (*n* =288)	5	32	54	9
Q38	often use computers at work (*n* =289)	4	27	57	12
Q39	have many job opportunities (*n* =290)	4	17	63	16
Q40	are needed all over New Zealand (*n* =290)	2	12	61	25
Q41	make things that help daily life (*n* =290)	2	7	61	30
Q42	will help development of New Zealand (*n* =289)	3	7	58	32
Q43	have high status in New Zealand society (*n* =289)	5	33	54	8
Q44	A career in engineering would be interesting (*n* =291)	10	19	54	17
Q45	Engineering requires better mathematics and physics than I am capable of (*n* =288)	7	27	40	26

The responses recorded in Table 4.11 suggested the students had a generally positive attitude towards engineering, in that there was considerably greater agreement than disagreement in many of the areas questioned. The majority of the sample expected engineers to be well paid (Q36), with good job opportunities (Q39), and to be in demand across New Zealand (Q40). They also perceived engineers made things that were helpful in daily life and for the development of the nation (Q41 andQ42), and over 70% agreed that engineering is potentially an interesting career (Q44).

Despite the apparently positive impressions of engineering careers as suggested by the responses shown in Table 4.11, and the similarity of the response distributions with the sample's general career expectations as seen in Table 4.10, the students did register considerable disagreement with some of the questionnaire statements related specifically to engineers and/or engineering as a career or field of study. The responses related to whether engineers were highly thought of, and their status in New Zealand society, Q37 and Q43, received the most disagreement to any of the questions related to engineering. Nearly 40% of the respondents felt that engineers were not highly thought of and did not hold high status, and less than 10% strongly agreed to the contrary viewpoint. With respect to engineering as an interesting career, question Q44 received the largest amount of strong disagreement (10%) of any of the questions on attitudes towards engineers and engineering. The responses related to confidence in mathematics and physics, Q45, also suggested 66% of the students felt that their mathematics and physics was not good enough for engineering.

It might be expected that the students' attitudes towards a profession, or towards people working within a profession, would affect their choice of career or field of study. Hence the relationships between the students' attitudinal responses towards engineers and engineering, and their responses to the question asking whether they were considering engineering as their future, Q35, were analyzed using a series of one-way ANOVA. The results of these analyzes are summarized in Table 4.12.

Table 4.12: One-way ANOVA: Attitudes towards Engineering, and Considering Engineering as a Career

Survey Question	Question content	Q35 Are you considering engineering? (Mean) Yes	Maybe	No	ANOVA F	p	$\eta 2$
Q36	Engineers – are well paid	3.08	3.11	2.77	9.30	.000	.06
Q37	are highly thought of in society	2.89	2.84	2.45	12.47	.000	.08
Q38	often use computers at work	2.68	2.87	2.72	1.80	.167	.01
Q39	have many job opportunities	3.03	2.97	2.81	2.22	.110	.02
Q40	are needed all over New Zealand	3.11	3.12	3.05	0.33	.720	.00
Q41	make things that help daily life	3.21	3.23	3.14	0.60	.548	.00
Q42	will help the development of New Zealand	3.24	3.32	3.03	5.85	.003	.04
Q43	have high status in New Zealand society	2.89	2.71	2.53	4.69	.010	.03
Q44	A career in engineering would be interesting	3.50	3.06	2.31	55.98	.000	.28

The students' responses to each of the attitudinal items, Q36 to Q44, have been converted to a mean score by coding the choice responses as 1,2,3,4 to represent "strongly disagree", "disagree", "agree", and "strongly agree" respectively[53]. The results include the value of eta-squared as a measure of effect size in terms of variance accounted for in the relationship.

The results of the one-way ANOVA shown in Table 4.12 indicate that a number of questions have a statistically significant relationship with the choice of considering engineering as a career, namely Q36, Q37, Q42, and Q44. The relationship with the largest effect size ($\eta^2 = .28$) was related to Q44; "A career in engineering would be interesting". More than any other responses, the construct of interest created separation of the means between those who were considering engineering and those

[53] In performing this ANOVA (and also subsequent *t*-tests) it has been assumed that the interval between each response is the same, for example, the interval between options "strongly agree" and "agree" is the same as the interval between options "agree" and "disagree". This is unlikely as the data are ordinal, however, analyses using the non-parametric equivalent approaches resulted in similar patterns.

who had rejected it, with those considering a career in engineering reporting the highest mean score. The analyses regarding being highly paid (Q36) and that engineers are highly thought of (Q37) also show statistically significant differences in means, but their effect sizes were small.

The responses in Table 4.11 relating to Q45, “Engineering requires better mathematics and physics than I have”, aligned with the notions in the literature discussed in Chapter 2 in terms of students being insufficiently educated to pursue “science majors”. About two thirds (66%) of the sample were in agreement with the statement of Q45 and only 7% strongly disagreed. The responses to Q45 and Q35, “Are you considering engineering as a career or field of study?” were subsequently cross tabulated to explore the relationship between the responses to those two questions, and the results are shown in Table 4.13.

Table 4.13: Confidence with Mathematics and Physics and the Intention to Study Engineering

	Q35 Are you considering engineering as a career or field of study? Response choices (%)		
Q45 Engineering requires better mathematics and physics than I am capable of	yes	maybe	no
Strongly disagree (*n* =19)	32	26	42
Disagree (*n* =77)	17	53	30
Agree (*n* =116)	11	42	47
Strongly agree (*n* =76)	8	28	64

The data in Table 4.13 show a statistically significant relationship between the choices of the options for considering engineering (yes, maybe, no) and agreement that engineering requires better mathematics and physics than they are capable of, χ^2 (df = 6, N=288) = 24.07, p = .001 and a moderate effect size of Cohen’s w of 0.29. Of those who strongly agreed with the notion of Q45, only 8.0% were considering engineering as a career as opposed to the 64% who had already discarded the option. Of those who disagreed with Q45, 32% were considering a career in engineering.

Finally in this section on attitudes towards engineers and a possible career in engineering, the appeal of an engineering career was examined. The responses to Q46 set out in Table 4.14 clearly indicated that the students felt engineering was far more likely to appeal to men than to women.

Table 4.14: Students' Attitude towards the Appeal of Engineering to Males and Females

Survey Questions	Question content	Response choices (%)		
		W > M	W = M	W < M
Q46	Do you feel engineering as a career is more likely to appeal to women or to men (n =289)	2	24	74

The relationship between students' choices of options for considering engineering, Q35, and their responses relating to the appeal of engineering to men and women was examined using a Chi-square test. There was however, no statistically significant relationship between these variables χ^2 (df = 4, N=287) = 7.27, p = .122.

Summary of Attitudes towards Careers in General and Careers in Engineering

In summary, students' responses related to the students' attitudes towards careers in general, and also towards engineers and engineering as a career or field of study, suggest that they have a generally optimistic view of their future careers and a generally positive attitude towards engineering itself as a career. Many of the general characteristics which the students were looking for in their future careers were also perceived positively as characteristics of a career in engineering. The data also suggest, however, a number of areas where the students' apparent attitudes could deter them from enrolling into engineering programs. A large proportion of the sample seemed to have concerns over the status of engineers, their own ability to master the mathematics and physics associated with engineering, and indeed the appeal of engineering as a career for women: nearly three quarters (74%) of the sample believed it was more appealing to men than to women.

The following section explores the possible influences on the attitudes of students towards engineers and engineering.

RQ3. WHAT FACTORS DO YEAR 12 STUDENTS IN GREATER AUCKLANDPERCEIVE HAVE INFLUENCED THEIR ATTITUDES TOWARDS ENGINEERING AS A CAREER OR FIELD ON STUDY?

The factors that may have influenced the students' attitudes towards engineering would likely be both internal as well as external to the students themselves. The internal influences may be revealed through the further analysis of the results from the survey, analysis which explores possible links between some of the sample's demographics, for example gender and/or ethnicity, and the students' attitudes towards careers in general, towards careers in engineering, and whether or not they are considering engineering as a career or field of study. The external influences were considered as other demographics of the sample, for example science promotions schemes, and also the responses to question series Q47 to Q56, which directly asked the students who or what they perceived may have influenced their attitudes. Firstly the possible relationships between internal influences and the students' various attitudes are considered.

Attitudes Related to Gender

Analysis of the literature in Chapter 2 indicated gender differences in attitudes towards future careers in terms of using the Internet, anticipated job interest, interpersonal goals, salary and status. The males' and females' responses were consequently compared for several sets of responses: the expectations of high salary (Q26), the expectations of high status (Q27), and the ability to work internationally (Q29); attitude towards computer usage (Q31), the importance of having interesting colleagues (Q32), and the importance of working as part of a team (Q33). The results of these analyses are shown as Table 4.15. The mean scores for each question are reported, and the results of independent *t*-tests are also reported.

Table 4.15: Comparison between Males' and Females' Attitudes towards Their Future Careers

Survey Question	Question content	Gender	*n*	Mean	*SD*	*t*	*p*
Q26	I expect a high salary	Male Female	155 128	3.06 3.10	0.66 0.66	-0.47	.640
Q27	I expect high status from my career	Male Female	155 128	2.83 2.94	0.64 0.76	-1.27	.204
Q29	I expect to be able to work internationally	Male Female	155 128	2.99 3.21	0.69 0.63	-2.73	.007
Q31	I hope to use computers frequently at work	Male Female	155 128	2.92 2.74	0.85 0.76	1.80	.073
Q32	It is important to have interesting colleagues	Male Female	155 128	3.14 3.12	0.66 0.66	0.31	.754
Q33	It is important to work as part of a team	Male Female	156 127	3.24 3.32	0.75 0.70	-0.99	.321
Q34	I must find my work interesting	Male Female	156 129	3.55 3.60	0.59 0.66	-0.62	.538

The results in Table 4.15 indicate that both males and females responded in a similar manner to all these questions on attitudes towards careers in general. In fact this series of independent *t*-tests revealed only one statistically significant difference at the .05 level; females more than males expected to be able to work internationally, $t(283) = -2.73$, $p = .007$, with a small effect size $d = 0.33$[54].

Survey question Q35 asked in a direct manner whether the students were considering engineering as a career or field of study, and the students' responses, as recorded earlier in this chapter, were discussed with respect to possible relationships with the sources of knowledge about engineering. However, given the frequently reported imbalance of male and female participation in the field of engineering, as noted in the literature of Chapter 2, gender-related data were also sought from the responses

[54] Cohen (1988) suggests that an effect size of $d = 0.20$ is small, 0.50 is medium and 0.80 is large.

to Q35. Table 4.16 shows the students' response choices as percentages, broken down by gender.

Table 4.16: Response Distribution by Gender towards Engineering as a Career or Field of Study

Survey Question	Question content	Gender	Response choices (%) Yes	Maybe	Not at all
Q35	Are you considering engineering as a career or field of study?	Male (n =155)	19	48	33
		Female (n =128)	5	32	64

Table 4.16 reveals that the ratio of proportional percentages of males to females considering engineering as a career was about 4:1, proportionally nearly twice as many females than males had already rejected engineering, and proportionally fewer females than males were undecided. This different pattern of responses is statistically significant, χ^2 (df = 2, N=283) = 29.99, p = 000, with a medium effect size using Cohen's w of 0.32[55].

The frequencies of the students' attitudinal responses towards engineering as a possible career were reported earlier, and analysis of the literature of Chapter 2 related specifically to attitudes towards careers in engineering suggests differences between male and female attitudes. Consequently, comparisons were made between males' and females' feelings about whether engineers were well paid (Q36); the status of engineers (Q37 and Q43); whether engineers make things that help daily life (Q41); whether engineering would be an interesting career (Q44); their confidence in their mathematics and physics capability (Q45); and the appeal to men and women of a career in engineering (Q46). The results of this further analysis are shown in Table 4.17 and Table 4.18.

Table 4.17: Responses Distribution by Gender of Attitude towards Engineers and

[55] As noted previously, Cohen (1988) suggested that for w, 0.01 be considered a small effect, 0.30 a medium effect, and 0.50 or greater, to be a large effect.

Engineering as a Career

Survey Question	Question content	Gender	*n*	Mean	*SD*	*t*	*p*
Q36	Engineers – are well paid	Male Female	156 129	2.89 3.02	0.73 0.61	-1.54	.125
Q37	are highly thought of	Male Female	155 127	2.63 2.71	0.77 0.64	-0.97	.333
Q41	make things that help daily life	Male Female	156 128	3.06 3.33	0.70 0.56	-3.20	.002
Q43	have high status in New Zealand	Male Female	156 127	2.57 2.74	0.75 0.63	-2.04	.043
Q44	A career in engineering would be interesting	Male Female	156 129	2.87 2.64	0.83 0.87	2.26	.025
Q45	Engineering requires better mathematics and physics than I am capable of	Male Female	154 128	2.81 2.95	0.95 0.81	-1.32	.180

The results in Table 4.17 show females tended to respond more positively than males to all these questions, except that engineering would be an interesting career, Q44. However, only Q41 (engineers make things that help daily life) and Q43 (engineers have high status in society) demonstrated statistically significant differences. These differences favoured females, and had effect sizes of d = 0.38 and d = 0.24 respectively. Males showed more agreement towards engineering as a potentially interesting career, and this difference was also statistically significant, with a small effect size of d = 0.27.

There was no gender-related difference in students' responses to Q45, "Engineering requires better maths and physics than I am capable of". A number of other analyses were carried out to explore the relationships between the responses to Q45, and school type, ethnic background, amount of time spent in New Zealand education, and subject streams studied at school. However no statistically significant differences were apparent.

The distribution of the responses to Q46, which asked the students whether they felt engineering appealed to women more than men, men equally to women, or men more than women, were analysed by gender and are shown in Table 4.18.

Table 4.18: The Appeal of a Career in Engineering as perceived by Males and Females

Survey Question	Question content	Gender	Response Choices (%)		
			W>M	W=M	W<M
Q46	Do you think engineering is more likely to appeal to women or to men?	Male (n =155)	1	26	73
		Female (n =128)	3	20	77

The results show very clearly that the male and female students felt that engineering was more likely to appeal to males more than females.

In summary, the results in this section indicate similar responses by females and males to most questions, and there was little difference in their attitudes towards engineers and engineering as a career. The only statistically significant differences were that females, more so than males, felt engineers made things that were helpful to daily life, and that engineers were highly thought of. On the other hand, males appeared more convinced that a career in engineering would be interesting. The majority of male and female students agreed that engineering was more likely to appeal to men more than women.

Attitudes Related to Ethnic Background

Enrolment into tertiary programs by students from selected ethnic backgrounds within the New Zealand context was discussed in Chapter 1, and Table 1.2 indicated Pākehā and Māori were proportionately under-represented in the fields of engineering and IT. Consequently, the sample's responses to whether they were considering engineering as a career or field of study, Q35, were analyzed by ethnic background, and the results are shown in Table 4.19.

Table 4.19: The Relationship between Ethnic Background and Students' Responses to Considering Engineering as a Career

Survey Question		Q35 Are you considering engineering as a career or field of study? Response choices (%)		
Q5	Ethnic background	Yes	Maybe	Not at all
	Pākehā (*n* =131)	11	39	50
	Chinese (*n* =15)	13	34	53
	Indian (*n* =20)	40	50	10
	Māori (*n* =24)	4	29	67
	Other Asian (*n* =19)	16	47	37
	Pasifika (*n* =29)	21	48	31
	Other (*n* =53)	8	41	51

The Ethnic composition of the sample is diverse, as shown in Table 4.19, and around 30% of the cells contain small numbers. However, a Chi-square analysis indicates that there is a statistically significant relationship between ethnicity and choice of career, χ^2 (df = 12, N = 289) = 28.15, p = .005, and the effect size is moderate (Cohen's w = 0.31). Cautiously interpreted, the response pattern suggests that Pākehā and Māori students showed the least interest in engineering with just 11% and 4% respectively responding "yes", whereas 40% of the Indians indicated that were considering a future in engineering. Of those who rejected engineering, Pākehā, Chinese, and Māori had proportions of 50% or greater, yet rejection of engineering by Indians was only 10%. It must be repeated that these findings are based on small numbers for the non-Pākehā groups, so these varied responses must be interpreted as suggestive rather than firm indicators of intention.

The students' attitude towards engineers and engineering would likely impact on any career choice. Hence, given the suggested relationship between ethnicity and engineering as a career, responses to questions Q36 to Q45 were analysed by ethnicity. For the most part these analyses revealed no statistically significant trends, however the responses related to how engineers were thought of were statistically significant, and are shown in Table 4.20.

Table 4.20: Attitude towards Engineers and a Career in Engineering Distributed by Ethnic Background

Survey Question		Q37 Engineers are highly thought of Response choices (%)			
Q5	Ethnic Background	strongly disagree	disagree	agree	strongly agree
	Pākehā (*n* =131)	6	37	52	5
	Chinese (*n* =15)	0	27	60	13
	Indian (*n* =20)	0	20	60	20
	Māori (*n* =24)	13	52	35	0
	Other Asian (*n* =19)	0	17	56	28
	Pasifika (*n* =29)	7	21	55	17

The analysis of the cross tabulated data of questions Q5 and Q37 shown in Table 4.20 indicates that the attitude towards engineers is not consistent across the ethnic backgrounds, and that the relationships show statistically significant trends, χ^2 (df = 18, N = 288) = 34.34, p = .011 with a moderate effect size, Cohen's w = 0.35. Māori students showed considerable disagreement with the notion that engineers are highly thought of, and none of them strongly agreed. The Pākehā contingent was also inclined to this perception, with 43% disagreeing that engineers are thought of highly. By contrast, the responses from the groups of Asian students were more favourably disposed to high status for engineers. Indians students responded most positively with 80% agreeing with the notion of high status for engineers, and the "Other Asian" sector of the sample population recorded the highest mean at 3.11 out of a maximum of 4.00. Again however, these findings are based on small numbers and so caution must be taken with the interpretations.

In summary, this section of the results explored relationships between the gender and ethnicity of the sample which could be described as internal influences, and the students' attitudes towards engineers and engineering as a career. Data related to gender and ethnicity exhibited statistically significant relationships with respect to several questionnaire items including Q35: Are you considering engineering as a career or field of study?, and Q37: Engineers are highly thought of in society.

External Influences on Attitudes towards Engineering

The relationships between the existence of science and engineering promotion schemes within their school, the decile ratings associated with the students' schools, and students' responses about whether or not they were considering engineering as their future career or field of study were examined, and Table 4.21 and Table 4.22 report the findings.

Table 4.21: The Relationship between Science/Engineering Promotion Schemes and the Students' Consideration of Engineering as a Career

Survey Question		Q35 Are you considering engineering as a career or field of study? Response choices (%)		
Q2	Is your school part of science and/or engineering promotion?	Yes	Maybe	Not at all
	Yes (n = 63)	16	36	48
	No (n = 149)	11	47	42
	Don't know (n = 73)	15	33	52

The pattern of the responses relating consideration of engineering as a career and whether or not a school was part of a science and engineering promotion scheme are shown in Table 4.21. The data suggest that for those students who were part of a promotion scheme, a greater proportion were considering engineering than those who had not been part of a promotion scheme. However, a greater proportion of those students experiencing the promotion scheme had also decided against a career in engineering than those who had not been part of a promotion scheme. Perhaps not surprisingly there was no statistically significant relationship indicated no statistically significant relationship χ^2 (df = 4, N = 285) = 5.07, p = .280.

Table 4.22 records the distribution of responses to a career in engineering across the range of school decile ratings combined into three clusters. The decile levels were clustered due to the low numbers of students in some of them.

Table 4.22: Relationship between School Decile Rating and Students' Consideration of Engineering as a Career

School decile rating	Q35 Are you considering engineering as a career or field of study? Response choices (%) Yes	Maybe	No
Decile 1-3 Low (n =32)	13	55	32
Decile 4-7 Med (n =131)	16	32	52
Decile 8-10 High (n =125)	10	43	47

The data of Table 4.22 suggest that school decile rating has little influence on the students' aspirations towards engineering as a career or field of study, and the relationship was not statistically significant, χ^2 (df = 4, N = 286) = 5.25, p = .263.

In summary, the sample's demographics which were considered as external influences on the students' attitudes, appeared to have minimal impact on their considerations of whether or not to follow engineering as a career or field of study.

The following section examines data related to the series of questions Q47 to Q56, which were designed to elicit responses on the perceived influences of family, friends, and a variety of other possible influences on their choice of engineering as a career. Personal influence was primarily categorized as immediate family (Q47) and other relatives, (Q48), and then friends/peers (Q49) and mentors (Q50). Alternative, impersonal, sources of influence from such as advertising or the media were suggested as TV (Q51), the cinema (Q52), magazines and newspapers (Q53), and shopping for electrical equipment (Q54), and the extent of the respondent's personal research was canvassed (Q55). The students were also asked who they felt was the most important person with whom they had discussed their career (Q56).

As questions Q47 to Q55 relate specifically to those had considered pursuing engineering, it was intended to invite those students who had never considered a career in engineering to skip to question Q56. Unfortunately, due to a typographical error, the students were instead instructed to skip to Q55, which was the question related to personal research into engineering. Some students did as instructed but others realized the error so did not answer Q55. As a result of the error, the size of the subset who responded to Q55 is different from both the total sample and from the subset who had at some time considered engineering as a career or field of study.

Table 4.23 shows the frequency of the responses to the questions asking who or what they felt had influenced their attitudes towards engineering as a career or field of study, Q47 to Q55. The subset sizes are provided in parentheses.

Table 4.23: Perceived Influences on Attitude towards Engineering by Those who Had Considered Engineering as a Career

Survey Question	Influence on career choice	Responses choices (%)			
		none at all	small extent	some extent	great extent
Q47	Family (n = 167)	35	30	26	9
Q48	Other relatives (n = 167)	41	28	24	7
Q49	Friends / Peers (n = 167)	46	27	20	7
Q50	Mentors / personal guide (n = 167)	52	25	18	5
Q51	Television (n = 167)	35	35	24	6
Q52	Cinema (n = 167)	55	23	17	5
Q53	Magazines / newspapers (n = 167)	44	27	24	5
Q54	Shopping for electrical equipment (n = 167)	37	24	31	8
Q55	Personal research (n = 257)	48	19	21	12

The responses to questions Q47 to Q55 recorded in Table 4.23 show that none of the sources listed stands out as having greatly influenced career decisions. In fact for every potential influence on career choice suggested, the highest percentage response choice is "none at all". It was also noted that 53% of the sample, 155 students, responded "definitely yes" or "maybe" to Q35 asking "are you considering engineering as a career or field of study", yet the subset for this series of questions, who purported to at some time in their lives considered engineering was 167 students. This suggests that an additional 12 students had at some time considered engineering but had rejected it by the time they were completing the questionnaire.

The relationships between the suggested influences on the students' decisions to follow a career in engineering, and their reported career decisions are the subject of Table 4.24. In this case the students are separated into two groups: those who had decided to take engineering, and those who were still undecided or had rejected engineering.

Table 4.24: Relationship between Influences on Students Career Decisions and whether the Student had Decided to Follow a Career in Engineering

Survey Question	Influenced by:	Are you considering a career in engineering?	*n*	Mean	*SD*	*t*	*p*	Cohen's *d*
Q47	parents and/or siblings	No/Maybe Yes	137 33	1.94 2.76	0.91 1.06	4.49	.000	0.87
Q48	other relatives	No/Maybe Yes	136 33	1.84 2.48	0.91 0.97	3.61	.000	0.70
Q49	Friends	No/Maybe Yes	136 33	1.76 2.39	0.90 1.09	3.50	.001	0.68
Q50	mentor/ personal guide	No/Maybe Yes	136 32	1.61 2.34	0.79 1.15	4.29	.000	0.83
Q51	Television	No/Maybe Yes	137 33	1.91 2.36	0.89 0.93	2.60	.010	0.50
Q52	Cinema	No/Maybe Yes	137 32	1.65 1.94	0.89 0.98	1.62	.107	0.33
Q53	magazines/ newspapers	No/Maybe Yes	137 32	1.83 2.19	0.90 1.03	1.96	.051	0.38
Q54	shopping for electrical equipment	No/Maybe Yes	136 33	1.99 2.48	0.97 1.00	2.60	.010	0.50
Q55	personal research	No/Maybe Yes	222 35	1.77 3.23	0.98 0.84	8.35	.000	1.51

The results of Table 4.24 indicate that seven of the nine suggested influences on career decisions and engineering as a career had statistically significant relationships, with questions Q47 (parents/siblings), Q50 (mentor/guide), and Q55 (personal research) exhibiting large effect sizes, with Cohen's *d* exceeding 0.80. In addition, the relationships with relatives (Q48) and friends (Q49) have moderate effect sizes of 0.70 and 0.68 respectively.

Finally for this section, Table 4.25 shows the responses to Q56 which asked the students who they felt was the most important person with whom they had discussed their career, and Table 4.26 reports the analysis of those responses with regard to considering a career in engineering.

Table 4.25: Relative Importance of People with Whom Students discussed Their Career.

Survey Question	Question content	Responses choices (%)					
		No one	Close family	Other relative	Friend	Mentor guide	Career advisor
Q56	Most important person with whom you have discussed your career (*n* =291)	13	55	4	12	4	13

Although close family members were indicated as the most important people with whom careers had been discussed, given that only 33 of the 291 students responding to this question had chosen engineering as a career, it seems that the advice did not strongly advocate engineering (see Table 4.23, Q47: Family).

It is shown more clearly in Table 4.26 with the cross tabulated responses to Q56, “who was the most important person with whom you discussed your career?”, and Q35, “are you considering engineering as a career or field of study?”

Table 4.26: Relationship between the Most Important Person with Whom Careers Were Discussed, and whether the Student had Decided to Follow a Career in Engineering

Survey Question		Q35 Are you considering engineering as a career or field of study? Response choices (%)		
Q56	Who do you feel was the most important person with whom you discussed your career?	Yes	Maybe	Not at all
	No one (n =39)	3	31	66
	Close family (n =155)	16	39	45
	Other relatives (n =12)	25	25	50
	Friends (n =33)	18	45	37
	Mentor/guide (n =11)	0	27	73
	Career advisor (n =39)	8	59	33

Although the results in previous tables suggested these influences were perceived as having had little apparent effect on the students' career decisions, a Chi-square analysis indicates that there was a statistically significant relationship between the most important person with whom careers were discussed and the students' choices of career, χ^2 (df = 10, N = 289) = 21.66, p = .017, but the effect size is small with Cohen's w = 0.27. In terms of choosing engineering it appears that of those who did, the advice was more likely to come from close family, relatives and friends.

The penultimate question of the survey, Q57, asked the students to indicate the field of their likely career, the responses to which are recorded in Table 4.27.

Table 4.27: The Students' Likely Major Career Fields as Percentage of Cohort

		Response Choices (%)										
Survey question	Question content	Natural Sciences	Engineering Architecture Technology	Agriculture/ Environment	Health	Education	Business	Society	Religion	Creative arts	Services
Q57	Likely major field of study (n = 286)	6	31	2	16	5	5	5	0	17	11

The responses to Q57 show that the highest percentage, 31% of the sample, favoured a career in the field of engineering and technology, and the next most popular fields were creative arts and health with 17% and 16% respectively. Although 31% appears to be a large portion of the sample, compared with the 13% who indicated they were definitely considering engineering as a career (see Table 4.6), in Q57, engineering was defined as engineering/architecture/technology, and was likely to be interpreted more broadly.

To explore the similarity of this New Zealand sample with career patterns as previously discussed in Chapter 2, the responses to Q57 were further broken down by gender and the results of this analysis are shown in Table 4.28.

Table 4.28: The Students' Likely Career Fields Distributed as Percent by Gender

	Q57 Likely major fields of study **(%)**									
Q3 Gender	Natural Sciences	Engineering Architecture Technology	Agriculture/ Environment	Health	Education	Business	Society	Religion	Creative arts	Services
Male (*n* =152)	56	81	57	35	13	64	36	0*	33	65
Female (*n* =128)	44	19	43	65	87	36	64	100*	67	35

* The field of religion was selected by only one student.

The data of Table 4.28 suggest that males tended to prefer the fields of science, engineering and technology, and business, more than did females, whereas females tended to favour the fields of health, education, society, and the creative arts. The author notes that the option of "services" was ambiguous and may have been interpreted by the students as either "the services industry" or "military services", consequently no further comment or conclusion is attempted regarding the responses in this field.

The final question of the survey, Q58, was open-ended, inviting the students to make further comments regarding their future careers. Very few responses were returned for Q58, and most of the comments were unrelated to this research, hence no further analysis of the text was followed. It was, however, encouraging that one respondent wrote that completing the questionnaire had made him/her reconsider engineering as a possible career.

In summary, the data related to the potential influences on the students' attitudes towards careers in general and towards engineering as a career of field of study, indicate that close family members were the most important people with whom career choice was discussed, of the suggested sources of influence, the students' responses suggested that personal research had the greatest relationship with actual career decision.

In the following chapter conclusions are drawn from the findings of the survey presented in this chapter, and discussed from within the context of the research literature previously discussed. Recommendations are made which may help enable students to follow a career in engineering, and guide the promotion of engineering as a better understood and more valued career or field of study to a wider New Zealand audience.

CHAPTER 5

RESEARCH CONCLUSIONS AND RECOMMENDATIONS

INTRODUCTION

This chapter begins with an overview of the research conducted for this thesis with Year 12 school students from the Greater Auckland Region of New Zealand. The discussion then moves to a summary of the findings, which are examined within the context of the literature reviewed in Chapter 2, and to the conclusions which are drawn in terms of the research questions and implications for careers advisors. Next, is presented a reflection on the effectiveness of the research method adopted, and finally for this chapter, implications for practitioners in the field of engineering and researchers into similar topics are outlined, and directions for further research suggested.

This research was designed to answer the following research questions:

RQ1. What do Year 12 students in Greater Auckland know of careers in engineering?

RQ2. What are the attitudes of Year 12 students in Greater Auckland towards engineering as a career or field of study?

RQ3. What factors do Year 12 students in Greater Auckland perceive have influenced their attitudes towards engineering as a career or field of study?

RQ4. Based on the findings of this research, what are the implications for school careers advisors, and others advising students on the choice of careers in engineering and related technical fields?

OVERVIEW OF THE RESEARCH

A survey research design was chosen as the most appropriate method of collecting data related to the knowledge and attitudes about careers in engineering of senior school students (Year 12) in New Zealand. A stratified random sampling approach was used to achieve a manageable, representative sample of Year 12 students from schools within the Greater Auckland region.

The survey was a self-administered online questionnaire composed of 58 questions which were completed by the students under the supervision of their school staff. The survey items were devised on the basis of a comprehensive review of the literature about choices of careers in engineering and related disciplines. The questionnaire contained five main themes: the demographics of the sample; the respondents' knowledge about engineering and how that knowledge was gained; what were their general career expectations and how they felt a career in engineering might relate to those expectations; who or what they perceived may have influenced their attitudes towards engineering as a career or field of study; and whether or not they were considering engineering as a career and what was their likely field of study. Prior to conversion to an online format, the questionnaire was tested for face validity with a group of science educators, and reviewed for clarity by some students of similar ages to those of the Greater Auckland sample.

The students to take part in the survey were from schools selected at random from the New Zealand MOE *July School Roll Returns* (2007), and the Principals who agreed that their students could participate were supplied with the appropriate information sheets and details explaining how to access to the questionnaire. Sufficient schools were selected to enable a potential sample of 888 students, from which at least 377 students were expected to complete the questionnaire. The 377 completed returns would have been sufficient to give a 95% level of confidence that the survey results would be indicative of the Year 12 population of Greater Auckland as a whole.

The survey period commenced in May 2010 and was suspended at the end of September 2010, but despite follow up contact with staff in the schools that had agreed to participate, only 292 responses had been returned. A decision was made not to contact additional schools as this would delay the progress of this research with no guarantee that the additional schools contacted would actually participate.

RESEARCH FINDINGS AND CONCLUSIONS

The data obtained from the survey were converted to a spreadsheet and the analysis undertaken using SPSS.

The demographic data indicated that approximately 43% of students were in high decile (8-10) government schools, 45% in medium decile schools (4-7), and 11% in low decile schools (1-3), with 1% from the private sector. The sample included 157 males (54%) and 129 females (44%). The largest ethnic group was Pākehā (45%), with Māori, Pasifika, Chinese, Indian, and other Asian each forming 5% to 10% of the sample (see Table 4.1 for detailed figures). From the original enrolment data used to determine the research sample size from the Year 12 population (see Table 3.1), it can be seen that the actual male to female ratio was approximately 49:51. Further examination of the data available online from *EducationCounts* (2007) showed that the largest ethnic grouping in Year 12 was Pākehā at 37%, with Māori 9.4%, Pasifika 23%, and Asians (grouping Indian, Chinese and other Asian) 24%. No ethnic background data were available regarding school decile numbers by year of study. Based on gender and ethnic background, there are similarities between the composition of the sample of students who responded to the survey, and to the population of Year 12 students in Greater Auckland schools in 2007 from which the original sample was derived. However, it is acknowledged that the final sample size, and the variations within the sample with respect to the population the sample was intended to represent, limit the generalizability of the findings. These, and other limitations to the generalizability of the findings, are discussed later in this chapter.

The findings of the research are summarized for each research question in turn.

RQ1. WHAT DO YEAR 12 STUDENTS IN GREATER AUCKLAND KNOW OF CAREERS IN ENGINEERING?

RQ1 was addressed through survey questions Q9 to Q25 (see copy of the electronic questionnaire, Appendix C) which sought to clarify the level and accuracy of the students' knowledge of engineering, and the sources from which that knowledge had been gained.

The Engineering-Related Knowledge of the Greater Auckland Students

The survey responses indicated that the students had a generally good understanding of the characteristics of a career in engineering. A large majority of the sample correctly perceived engineering as a male-dominated fraternity, were aware that engineering was offered at universities and other institutions, and were aware that a variety of fields of engineering existed as courses at both under-graduate and post-graduate levels. They also considered that engineers made a positive contribution to society (see Table 4.3). Only about half of the sample was sure that New Zealand needed more engineers and that New Zealand engineering qualifications were recognized overseas. Although more than two thirds of the students were aware of the design aspect of engineering, there appeared to be some confusion within the remainder between the type of work done by engineers and that done by mechanics or technicians.

Comparison with findings from other countries suggested that the engineering-related knowledge of the New Zealand sample appeared to be greater than their Australian (as represented by research carried out in the state of Victoria), UK, and US counterparts. The literature reviewed in Chapter 2 indicated that many of those surveyed in the UK lacked awareness regarding engineering, while the Australian students felt they lacked understanding of ICT and purported to experience difficulties in accessing engineering-related information. Although the youth within the sample involved with the RAE research in the UK (Marshall et al., 2007) seemed confident in their ability to access information through the internet, they were not confident in the accuracy of their knowledge. This lack of confidence was deemed due to the perceived ambiguity in the types of work done by engineers: the 16- to 19-year-old group indicated that the source of their confusion was the misuse of the term *engineer* in job titles and job descriptions. This confusion about the type of work done by engineers was also evident in the responses by the New Zealand students in this study, which suggested that about one third of the sample perceived that engineers repair engines and/or appliances, or drive vehicles (see Table 4.3).

Of the sets of responses to other questions on knowledge of engineering, further analysis showed no statistically significant differences between male and female students' responses regarding the ratio of males to female engineers within the engineering profession, the perceived contribution of engineers to society, and whether or not New Zealand needed more engineers. This analysis suggests that overall, the male and female students of the Greater Auckland sample had a similar range of knowledge and understanding of engineering as a profession.

The Sources of Engineering-Related Knowledge of the Greater Auckland Students

The students' responses indicated that not many of them knew many engineers well. More than 87% of the students recalled knowing less than 5 engineers and only 20% had engineers as immediate family. It appeared that the opportunities for informed input from family members on the topic of engineering were limited. Of the less personal opportunities suggested as possible inputs to the students' knowledge, discussions with careers advisors registered the greatest frequency, while talks at school by engineers and/or industrialists appeared to be the least frequent.

There were contrasting responses regarding the effectiveness of school careers advisors in New Zealand. The Greater Auckland sample in this research indicated that nearly 40% of them had discussed engineering as a possible career, but only 13% considered careers advisors to be the most important person with whom they had discussions (see Table 4.25). In their report to IPENZ, Shagen and Hogan

(2009) indicated that the first year science students ranked careers advisors as almost the least beneficial, that is to say, 14^{th} out of 15 from their list of beneficial sources of engineering-related knowledge. The respondents to the Shagen and Hogen (2009) survey did, however, concur with their UK counterparts, in agreeing that talking to people who worked in the field they wished to study was the most beneficial source of career information.

In summary, the Greater Auckland students of the sample seemed generally well informed about the characteristics of a career in engineering. The majority understood some aspects of the type of work of an engineer, the likely working environment, and opportunities for study. Some students were confused between the work done by engineers and that done by tradesmen, and also regarding the beneficial nature of some sources of knowledge. These issues will be further highlighted in the section on implications and recommendations for practitioners in the field of engineering, which is contained within the section related to RQ4.

RQ2. WHAT ARE THE ATTITUDES OF YEAR 12 STUDENTS IN GREATER AUCKLAND TOWARDS ENGINEERING AS A CAREER OR FIELD OF STUDY?

Survey questions Q26 to Q46 were designed to reveal the proportions within the sample that were inclined to follow engineering as career, and also the possible relationships between the sources of knowledge, how the sources of knowledge and the students' attitudes might appear to impact on engineering as a choice of career, and the students' attitudes towards engineers and engineering.

Students' Responses to the Question of Engineering as Their Possible Career or Field of Study

Students' responses indicated that 13% of the sample had decided to follow a career in engineering and that almost half of them had already rejected the option. Of those who indicated that they wanted to follow an engineering career, proportionately 19% of the responses were from the males within the sample, and 5% were from the females within the sample (see Table 4.16). Approximately 40% of the students however were still undecided, a proportion which is considerable and which might be influenced by a focused recruitment drive. Further, even the potential enrolment of 13% of the tertiary intake into engineering programs would be approximately double the recent enrolment figures for New Zealand, where the statistics showed that the actual enrolment into engineering and IT at the tertiary level from 2003 to 2009 had declined from approximately 8% to 6% respectively. Declining enrolment into engineering and related technologies, either as absolute numbers or as a proportion of the total, had also been reported over a similar period from research in the UK, the US, and Australia. It should be noted however, that the 13% of the Greater Auckland sample who indicated they would follow a career in engineering was only theoretical enrolment, the actual career choices of the Greater Auckland students on leaving school two years later, are unknown.

Relationships between the Sources of Students' Knowledge and Their Choices of Engineering as a Career

Analysis of the students' responses showed a statistically significant relationship between how many engineers the students knew well, and the students' inclination to follow a career in engineering. Proportionately, those students who indicated they knew engineers well were more likely to follow a career in engineering than those who did not know engineers well, by a ratio of 6:1. Having an engineer in the family also had a statistically significant positive effect on potential enrolment into engineering programs. It is difficult to draw conclusions from this information other than to suggest that those who are already in the field of engineering appear to be encouraging others to become engineers. Such a conclusion concurs with the findings of the report in Australia on the attitudes to ICT careers (OMRG, 2009), and the study by Marshall et al. (2007) in the UK. The Australian report commented that the principal influences on a student's career choice were likely to be people working in the field, their parents, and work experience; a notion echoed from the UK where the respondents indicated that key sources of knowledge were word of mouth from family and friends who worked in the industry.

Statistically significant positive relationships were also detected between choosing engineering as a career, and where students had attended public seminars, read publications, visited engineering/industrial sites, attended talks about engineering, or engaged in personal research about engineering (see Table 4.9). However, the question items used for this research were able only to establish these relationships, and it is impossible to know whether those students who responded positively to these influences were motivated towards a career in engineering, or whether the students were already interested in engineering and so attended the seminars, and were attracted to other sources of information.

Students' Attitudes Towards Careers in General

The students in the sample exhibited a generally positive regard for their potential careers in terms of salary, status, continuous employment, helping their country, and of obtaining interesting work. The least positive responses were to the notion of using computers frequently at work, but even for this question, twice as many students appeared to be looking forward to using computers than those who were not. The conclusion from the responses to these questions, which related to careers in general, is that this sample of students had fairly positive expectations for their future careers, and that the majority were comfortable with the use of computers, and hoped for it to be a part of their future career.

Students' Attitudes towards Engineers or a Career in Engineering

The students' responses to the questions related to engineers and engineering indicated a fairly positive attitude towards engineering as a possible career, and their responses mimicked many of the expectations they had for their careers in general. Good salary, job opportunities, contribution to daily life and the nation's development, employability, and interesting work, all received high proportions of responses in agreement, within the context of a hypothetical career in engineering. It is noted that in relation to the students' attitude towards engineering, the notion of interesting work had the greatest effect size ($\eta^2 = .28$, indicating that this relationship accounted for just over a quarter of the variance in responses). Of all the questions in this section, responses to the notion of interest had the highest mean returned by those students who intended to follow a career in engineering, and the lowest mean was returned by those who did not (see Table 4.12). The students' responses were less positive about the status of engineers and the perceived difficulty of mathematics and physics (see Table 4.13); and a high percentage of the sample also indicated they felt engineering was more likely to appeal to men than to women (see Table 4.14).

The result showing that only 8% of the sample strongly agreed that engineers have high-status in New Zealand society (see Table 4.11) contrasted with much of the literature reviewed. In the US, engineering was reported as being viewed as a career which afforded high status (Morgan et al., 2001), similar sentiments were found in the literature from the UK, and from research reviewing Western European employment, in which Baranowska and Unt (2012) concluded that there were employment benefits for engineering graduates. In Australia however, it was suggested that engineering was not well marketed and that engineers were not visible as an occupational group. Further analysis was performed on the relevant data, and the results discussed in the next section (relating to RQ3) which examines the perceived influences on the students' attitudes towards careers in engineering.

With regard to the students' concerns about the difficulty of the mathematics and physics involved in engineering programs, subsequent scrutiny of the schools' enrolment data revealed that from 2003 to 2009 about four times the number of students enrolled in mathematics than enrolled in physics, and that for each of the years reviewed, females made up approximately only one third of that enrolment into school physics. Further analysis was carried out on the enrolment data and is also reported in the next section.

The idea that engineering was more likely to appeal to males rather than to females, was so highly agreed upon by both sexes that no further quantitative analysis would have been fruitful. Such a result is, however, worthy of further investigation, and so is addressed again in section RQ4 which discusses recommendations for further research.

In summary, 13% of the sample indicated that they intended to pursue a career in engineering, and 40% indicated they were still undecided. Further analysis revealed that those who knew engineers well and/or had engineers in their family, were six times more likely to enroll in engineering programs than those who did not. The Greater Auckland students appeared to have a generally positive outlook for their future careers, and a generally positive attitude towards engineers and careers in engineering. Their responses were, however, less positive with respect to the status of engineers, that a career in engineering would be interesting, their ability to master the mathematics and physics required for engineering, and the appeal of engineering to women. These issues are further discussed in the following sections related to RQ3 and RQ4.

RQ3. WHAT FACTORS DO YEAR 12 STUDENTS IN GREATER AUCKLAND PERCEIVE HAVE INFLUENCED THEIR ATTITUDES TOWARDS ENGINEERING AS A CAREER OR FIELD OF STUDY?

The factors considered that may influence the students' attitudes towards engineering as a career were internal to the students, gender and ethnicity, and external to the students, for example family and friends or the students' preparation for tertiary engineering programs. In this section the internal factors are addressed first, after which the external factors are discussed.

Internal factors

Gender

The responses regarding knowledge and attitudes towards careers in engineering were largely similar for both males and females. However, analyses of the responses to the attitudinal questions also showed that a higher proportion of females did not consider a career in engineering would be interesting, and that females were less confident in their abilities with mathematics and physics than their male counterparts. Hence unsurprisingly, when responding to the question on their consideration of engineering as a career, the sample exhibited the typical male/female imbalance for Western industrialized nations as discussed in Chapter 2 and seen in Figure 2.1 and Figure 2.6. Proportionately, four times the number of males than females selected engineering as a potential career, and twice as many females than males had already rejected engineering as a career option (Table 4.16).

Ethnic Background

Although Pākehā was the only specific ethnic group containing more than 30 respondents (see Table 4.1), and so the analyses of the responses are interpreted cautiously, a statistically significant relationship was found between ethnicity and the choice of engineering as a career, and a statistically significant relationship was also apparent between ethnic background and the responses regarding the high status of engineers in New Zealand society (see Table 4.20). Pākehā and Māori appeared to be less inclined to become engineers than those of the other ethnic groups within the sample, and registered the highest disagreement regarding the notion of engineering being a high status career. The responses of Pākehā and Māori regarding the status of engineers were also contrary to the majority of the rest of the sample, and also to the findings of the literature. Given that Pākehā and Māori form approximately 80% of tertiary enrolment in New Zealand, and that they showed the least inclination of all groups to follow a career in engineering, such a finding requires further investigation. It is possible that Pākehā and Māori had similar reasons for their rejection of engineering as a career, and it is likewise possible that they had entirely different reasons. The responses to Q14 suggested that 26% of the cohort thought engineers repaired engines or other appliances. It could be that some students liked the notion of being and engineer and fixing engines, alternatively the perception that engineers are tradesmen rather than designers might have lead to a lowering of perceived status. Further research into the perceived status of engineers and the reasons behind the perceived status by different ethnic groups would provide more information.

External Influences

Family, Friends, and Advisors

As indicated earlier in this thesis, the survey contained a list of possible external influences on students' career decisions, including family and friends, the media, and school events. However, none of the external influences suggested to the students was perceived by them as having had much effect. To each of the suggested influences, the most common response was "none at all" and the least common was "great extent" (see Table 4.23).

The perception that the suggested influences made little or no difference ran contrary, however, to the analysis of the responses related to having engineers as relatives and the students' inclination to pursue engineering as a career (see Table

4.8). These analyses suggested a statistically significant link with family, either immediate family or relatives, for both choosing engineering as a career and also the importance placed on family advice. Such a result concurs with the literature reviewed from both Australia and the UK. The Australian students ranked family and friends highly in terms of beneficial information, and the RAE report from the UK by Marshall et al., (2007) indicated that family and friends were key sources of information.

Preparation Through School for Tertiary Engineering Programs

For most of the students surveyed, preparation through school for tertiary education would have meant enrolment into standard final year courses such as mathematics, English, and the arts. Some students (22%) however, indicated their school was part of a science promotion initiative. Although there was no statistically significant relationship between the school science promotion initiatives and the responses regarding choosing engineering as a career, science promotion did appear to help students come to some decisions about their possible careers. Of those who indicated they were involved with the promotion, a higher percentage had elected to enroll into engineering programs than those not involved in the science promotion. A higher percentage of students also indicated they would not enroll, than did those who were not involved in the promotional activity (see Table 4.21). It would appear the promotional scheme was clarifying issues for some of the students, and so fewer students from schools involved in a science promotion scheme remained undecided.

The relationship between the perception that mathematics and physics would be too difficult for many of the sample and their decision not to choose engineering as a career was statistically significant. Those students who felt they could master the subjects and were considering following a career in engineering were distributed yes, 32%; maybe, 26%; and no, 42% (see Table 4.13). However, of those 76 students who indicated a lack of confidence in their ability in mathematics and physics, only 8% intended to follow a career in engineering, whereas 64% had already rejected the option. Reviewing the schools' subject enrolment data (see

Table 1.3) revealed that while a high number of New Zealand students had persisted with mathematics in 2010, only a quarter of that number had enrolled for physics, and of those enrolled in physics only about 30% were female. Similar proportions were shown for the enrolments of 2001 and 2006. Hence it is understandable that a high proportion of students indicated that they lacked confidence in mastering the mathematics and physics required for engineering, as they were no longer studying physics. It is also understandable that females were less confident than males because less than half as many females as males were studying physics by Year 12.

The reports related to confidence in mathematics and physics that were reviewed in the literature indicated similar findings. In the US, the NCES Web site showed data which revealed a decline in attainment in science subjects from 1996 to 2005, and in the UK, the declining interest in school science was reported by Osborne and Dillon (2007) to the Nuffield Foundation. In Australia however, although the OMRG (2009) report did not contain comments specifically about mathematics and physics, there was an indication that the Australian students felt capable of pursuing courses in ICT. In other words, the students felt confident in their abilities at the schools subjects which underpin ICT, namely mathematics and physics.

Finally in this section which examined the relationships between external influences and the sample's choice of engineering as a career, the relationship between the students' career decisions and the school decile number showed no statistically significant difference. This suggests that the students' socio-economic environment was not a barrier to their aspirations of following a career in engineering.

The students were asked to indicate which was their preferred field of study, and in general their responses aligned with the analysis of the literature in Chapter 2. That is to say, females tended to favour society and arts programs and males tended to favour business and sciences. The responses showing that 31% of the sample indicated they were interested in engineering and technology does not run contrary to expectations. Table 1.4 showed that the courses now collectively referred to as technology at school ranged from computer programming to textiles, and hence it is likely that some students responded to technology as it is used within the schools' framework, and other students to technology as it may be interpreted within the tertiary framework. It is also possible that some students had a learning experience during the course of answering the questionnaire, as suggested by the one respondent who indicated that completing the questionnaire had made him or her reconsider engineering as a career option.

RQ4. BASED ON THE FINDINGS OF THIS RESEARCH, WHAT ARE THE IMPLICATIONS FOR SCHOOL CAREERS ADVISORS, AND OTHERS ADVISING STUDENTS ON THE CHOICE OF CAREERS IN ENGINEERING AND RELATED TECHNICAL FIELDS?

The answers to this final research question are based on the findings of the previous three. The focus is solely on the New Zealand context, that is to say, what recommendations might improve the enrolment of New Zealanders into Bachelor of Engineering programs. Although the sample was taken only from schools within the Greater Auckland region, this region represented more than 34% of the Year 12 population for New Zealand, and hence, with acknowledgement of the presence of large Pasifika and Asian student populations, is likely to give some indication of the responses that would have been returned from Year 12 students nation-wide.

The implications for those advising students on careers in engineering and related fields are discussed by topics which are grouped in a manner similar to the clusters of items within the questionnaire for this research. These topics are related to the students' knowledge, their attitudes towards engineers and/or a career in engineering, and the perceived influences on those attitudes.

Implications for Advisors as Related to the Students' Knowledge

The sample of Greater Auckland students showed generally good knowledge of engineering careers except for three areas: that engineering can be studied online and part-time, that at the time of the survey there was a shortage of engineers in New Zealand, and the type of work done by professional engineers.

The first two of these areas, modes of study and the demand for engineers, are factual and should be relatively straightforward to address through, for example, fact sheets and posters. The third area, type of work done by engineers, requires a deeper explanation in order to distinguish between the work generally done by engineers, mechanics, and other technical trades, and to promote the creative problem solving and intellectual aspects of engineering. Such explanations to students and the public, which are possibly outside the scope of schools' careers advice, are discussed later in this chapter in relation to implications from this research for engineering bodies.

Implications for Advisors as Related to the Students' Attitudes Towards Engineers and Engineering

The inclination of the students to choose engineering as a career was affected most positively by knowing engineers well or having an engineer in the family. Given this positive effect, it is important that students who may be inclined towards a career in engineering are encouraged through their schools to seek out engineers within their family or be provided with opportunities to meet engineers.

Visits to schools by engineers/industrialists appeared to be the least effective in terms of persuading students to enroll into engineering programs. Traditionally such visits tend to be a person on stage talking to a student audience en masse. An alternate strategy would be to organize young engineers to visit schools and to talk informally with small groups of students. Such a personal approach may have a greater impact on the students as they would have a better opportunity to get to know engineers *well*. If it is possible to create a schedule of visits, by or to the school to reinforce the relationships, this may also increase their effectiveness.

The attributes of a career in engineering which were identified by the sample as being positive should be highlighted in educational material about careers in engineering. That is to say, New Zealand students and their parents should be made more aware that a career in engineering affords a good salary, many and varied job opportunities, makes a positive contribution to daily life and to the nation's development, and is intellectual engaging.

The aspects of an engineering career which determine its social status, the perceived difficulty of mathematics and physics, and the lack of appeal of engineering to females, need to be better understood so that ways can be found to redress them. These, and other questions, are the subject of recommendations for further research, as made in a later section of this thesis.

Implications for Advisors as Related to the Perceived Influences on Students' Attitudes towards Engineering as a Career or Field of Study

The analysis of the sample's responses indicated that the most positive relationship with their career decisions was their family, and the most negative relationships with respect to a career in engineering were gender and ethnic background.

Indications of the strength of family input were evident from the responses to a number of questions within the questionnaire and also concur with the literature reviewed. Consequently targeting and enlightening parents of students interested in science careers could have a positive impact on enrolment in engineering programs.

The notion that gender is an important factor affecting attitudes towards engineering as a choice of career concurs with the literature reviewed. As the literature from the Western industrialized nations indicated, male enrolment into engineering programs outnumbers female enrolment by ratios varying from approximately 3:1 to 6:1. Affirmative action strategies have been implemented for more than a decade, for example the AWIS was established in New Zealand in 1985 and WIE was founded in New Zealand in 1991. The enrolment data reviewed earlier suggest that these and other initiatives appear to have had little effect on improving the gender imbalance within engineering, and so engineering institutions and associations need to continue their search for new and more effective approaches to this issue.

The comparatively lower status of engineers and engineering seemingly perceived by Pākehā and Māori students compared to the other groups of respondents runs contrary to the literature reviewed, in which engineering is perceived as a high status occupation. Without further investigation, the only conclusion at present is that the confusion by some students over the type of work done by engineers is undermining the perception of status. The potential for further research is discussed later in this chapter.

In summary, schools' careers advisors play an important part of raising the level of knowledge among students and parents about careers in engineering, and with clarifying the differences between tradesmen and professional engineers. Involving parents and family is likely to have a positive effect on the students' perception of engineering, as is arranging a series of opportunities for students to meet and interact with young engineers. Careers advisors should be aware that Pākehā, Māori, and females are under-represented in engineering, and so those particular groups should be encouraged to persist with senior school science, especially physics, and to attend opportunities to learn more about engineering careers.

In the light of the outcomes of this research, this chapter now continues with a reflection of the research method, and implications for alternate approaches for further research.

REFLECTIONS ON THE RESEARCH METHOD

The use of the online questionnaire proved to be highly effective and efficient as a method of collecting and logging data. The respondents indicated minimal access issues, did their own data entry, and the SurveyShare.com site formatted the data for uploading into SPSS. The time taken to convert the hard copy of the questionnaire into digital form was considerably less than the time that would have been required to enter the data from hard copy onto an electronic database. Another benefit of using a web hosted questionnaire is that once the electronic format is created, the volume of completed returns makes no increased demands on the effort required to gather, enter, prepare, and process the data. In addition, such an online approach to conducting surveys avoids the cost and time involved in printing, distributing and collecting hard copies of the questionnaire.

Access to the questionnaire was organized through the internal networks of those schools where permission had been obtained from the Principal for their students to participate. This approach meant that none of the students was disadvantaged through not being able to access the questionnaire, and also that the students were responding to the questionnaire in a safe environment; an important aspect of collecting data from students.

Those who completed the survey showed no signs of fatigue towards the end of questionnaire or irritation towards the content. The students appeared to answer the questions in an honest and reliable manner, in that there were no survey forms returned which contained a predominance of 'ticks' in any particular column, or all questions responded to with 'YES' or 'NO'. In general the questions appeared to be interpreted by the students as had been intended by the author.

Critically however, only 292 students completed the questionnaire instead of the 377 returns required to give a 95% level of confidence in the generalizability of the findings.

The number of returns was lower than expected indicating that the strategy for engaging with the schools' personnel had not been as effective as desired, several of the schools that indicated a willingness for their students to take part unfortunately did not in fact do so. However, given the crowded nature of the schools' curricula, this is understandable. During the field test of the survey, one school drew attention to "fire walls" being experienced as electronic barriers to accessing the survey, and it may be that other schools experienced similar problems, during the field test or during the actual survey, but did not report them.

Almost all of the students that took part were from schools within the public sector, with students from only one private school participating. It is not known if any of the schools had been contacted by IPENZ schools' liaison staff regarding this study, however it was noticeable that most of the students who participated were from those schools with which Dr. Hawk had a working relationship. There is little doubt that personal intervention by Dr. Hawk was a key factor in motivating the school Principals to permit and encourage their students to complete the questionnaire.

The ambition of this work when originally formulated was to better understand the career choices of New Zealand school students, and to use this understanding to help improve enrolment into Bachelor of Engineering programs. However, as a consequence of the research methodology adopted, the approach used in order to cope with limited resources, and the low number of completed questionnaires, the findings of this study are limited in terms of their generalizability.

The strategy of selecting schools at random from within population strata results in a statistical probability that the findings are reflective of the characteristics of the population as a whole: conversely however, there is also a smaller statistical probability that the sample is not representative of the population. The survey sample did not include students at special education schools or students in home-schooling/distance education mode. Restricting the survey to Year 12 students who attended schools within Greater Auckland further reduced the generalizability of the findings, but was a necessary strategy given the available resources. In addition it should be noted that 103 of the respondents came from the same school (see Table 3.7). Although students are being surveyed as individuals, and the school is merely a convenient and secure method of clustering them together, it is possible that some confounding variable related to that particular school might have influenced those 103 students. As discussed within the summary of the instrument administration, the responses from the 103 students and the responses from the remainder of the sample were analyzed separately to look for unusual traits in the respondents' demographics; none was found. Finally, in terms of the limitations to the generalizability of the results, 289 out of the 292 completed questionnaires came from the state education sector, of which 261 were from the co-educational schools.

As a consequence of the limitations just discussed and the low number of completed returns, and with reference to sample sizes a indicated by Sekaran (2002), the findings of this work can be inferred, at best, with a 95% level of confidence and a 5% error margin to Year 12 students from the Greater Auckland region attending schools within the state co-educational sector during 2009.

With respect to the questionnaire itself; self-completion questionnaires are open to measurement error caused, for example, by the respondent's accuracy of recall, truthfulness, and interpretation of the questions. Additionally, a questionnaire can only provide a finite number of predefined questions, and as such it is possible in this instance that other sources of knowledge or other influences on a student's choice of career may have been missed. In order to keep misinterpretations and the omission of questions on relevant topics to a minimum, the questionnaire was subjected to a walk-through with a group of school students in Oman who were of similar ages to the target population of Greater Auckland students. The Oman group consisted of males and females who had a variety of career aspirations. This procedure gave some confidence in the validity and clarity of the items on the questionnaire.

In summary, the self-administered online questionnaire had many positive characteristics including ease and flexibility of access by the respondents, and ease of data collection and processing once the electronic questionnaire had been created. The smaller than anticipated number of returns may have been the result of a number of factors including a perceived heavy student workload and the impersonal nature of the internet. In either case, the number of returns suggests that either greater personal interaction was needed to motivate participation, and/or a greater number of schools' Principals should have been contacted to request the participation of their students.

This chapter concludes with implications for practitioners from the conclusions to this research, and implications and recommendations for further research.

IMPLICATIONS FOR PRACTITIONERS AND FUTURE RESEARCH

Implications for schools' careers advisors were addressed previously in this chapter. A range of activities were suggested, including the creation of fact sheets, clarifying for the students the differences between the types of work done by technical tradesmen and by professional engineers, and finding ways to educate the students' parents about careers in engineering. Given that it is unlikely that many careers advisors have a background in professional engineering themselves, it is important that they keep themselves informed about changes in the engineering environment, particularly in terms of employment opportunities in the field.

Implications for Practitioners

Engineering bodies should champion their cause in partnership with the New Zealand education system, pursuing a strategy of engaging the public with engineers and careers in engineering. Each sector has its own responsibilities, but the sectors need to maintain frequent consultation with each other as they attempt to improve the public knowledge of, and public attitudes towards, engineers and engineering. It should be recalled that approximately 40% of the sample indicated they were yet to decide whether or not to follow an engineering career, and it is these undecided students who offer the largest group for potential recruitment into the field.

The crafting of a promotional campaign about careers in engineering seems to be more the responsibility of the engineering bodies and their marketing teams than of the MOE. It is engineers who have the in-depth understanding of the characteristics of careers in engineering and who, with advice from their target audience of prospective enrollees and their families, are equipped to design relevant content for information dissemination. However, at the schools' level, industry also has a part to play in keeping schools informed, and in designing promotional materials for display and distribution at the schools' careers offices.

Institutions providing opportunities for students to experience a working environment, for example if inviting students on an industrial visit, should also be aware that it is family that is likely to have the greater impact on the students' career decisions rather than the industry providing the visit. Hence those conducting the industry visit should, in addition to providing a stimulating experience, echo the careers advisors by encouraging students to consult family and engineers that they might know.

A number of steps may be taken to redress the situation of some students regarding engineering as a career with low status in New Zealand society. For example, IPENZ and associated engineering bodies could embark on a number of campaigns. First, a campaign clarifying the differences between the typical work of a professional engineers and tradesmen would educate parents and students alike about the nature and value of engineering. Second, a campaign targeting Pākehā and Māori, and specifically involving Pākehā and Māori role models, could assist improve the perception of these groups towards the status of engineering careers. Third, engineers could be encouraged to use the title *Engineer* in the same way as titles such as Doctor or Professor: the use of the title *Engineer* is already practiced in some countries and implies elevated status. The responsibility for the majority of such campaigns should rightly be with the engineering profession, however, the education sector should also be consulted and invited to collaborate in every possible opportunity.

The New Zealand government should also be involved. Legislation should be created to reserve the use of the term *engineer* to relate to those holding a Bachelor of Engineering degree, or when referring to work which would require the attention of someone holding such a degree. Second, government, industry, and academia should consider the redesign of the senior school and/or tertiary level learning environment. In 2011 the author visited Aalto University, Finland, on a fact-finding visit for the Ministry of Higher Education of the Sultanate of Oman. Aalto University had within its campus a senior school, equivalent to New Zealand Year 12 and Year 13, for selected students interested in science careers. The campus also housed a number of companies including Nokia, and an innovation and business incubation centre named *the Design Factory*. Such campus design, with the inclusion of a senior school, brings students with an inclination to pursue science degrees into closer contact with the realities of engineering. It removes many of the barriers between industry and academia, including the logistic hurdles of making arrangements for students to go on industrial visits. Such campus design also gives school students frequent opportunities to observe, discuss, and understand what it means to be an engineer, as well as giving context for school science.

Implications for Future Research

The implications for future research which come from this work are both methodological and topical. This research was quantitative in nature, and as previously noted, the use of an online questionnaire as a survey tool was very effective both in terms of ease of access by the respondents, and in terms of ease of data entry by the researchers. However, such an approach lacked the personal contact which can motivate participation. Despite many telephone calls by the author (who was located in Oman) to school Principals and/or careers advisors, and despite the apparent good will from all concerned, a number of schools where the Principal indicated their students would participate failed to do so. It was also apparent that those Principals with whom Dr Hawk (who was locally based) had a professional relationship and had previous personal interaction, and who agreed that their students would take part, did do so. This experience underscores the value of personal contact when eliciting cooperation in research projects.

Prior to considering ease of access and data entry, it is important that researchers plan a population engagement strategy in order to motivate potential respondents to participate in the survey, or in the case of research similar to this one, to motivate the Principals to give permission for their students to take part. A number of strategies are available which can improve the response percentages including contact face to face, by phone, and/or email, and/or incentives such as the donation of electrical gadgets, or tokens such as books or events tickets.

The findings of this quantitative research have highlighted a number of issues which require further investigation, including the perceived status of engineers, the perceived difficulty of engineering mathematics and physics, and the lack of appeal to women of a career in engineering. In order to build explanations for the findings of this work, it is recommended that future research be conducted in a qualitative manner, as focus group discussions and interviews for example, in order to gain a deeper understanding of the issues affecting New Zealand students' career choices. In particular, understanding why a career that was perceived as intellectually challenging, well paid, and helpful to daily life and national development by the majority of the sample, was also perceived by a significant proportion of the sample as having low status would be very helpful. Being able to design a strategy to address this issue could lead to a considerable increase in enrolment by domestic students into Bachelor of Engineering programs.

Further investigation in the area of subject selection in senior schools is warranted. The schools' enrolment data from the New Zealand MOE indicated that many students, especially female students, persist with high school mathematics but drop physics. A number of research questions arise from this topic, including whether or not the students are aware of how such a decision impacts of their future career options; a point raised by Marshall et al. in 2007. Many of the students in the Greater Auckland sample also indicated they felt their mathematics and physics would not have been good enough to cope with the demands of an engineering degree, even though they had not yet studied for engineering.

The lack of appeal of a career in engineering to women in New Zealand, as suggested by many of the males and females of the sample, reflects a trend in many Western industrialized nations. Despite the affirmative action efforts of institutions associated with the engineering professions of New Zealand and other countries, the percentage of females opting for engineering degrees remains low when compared to the enrolment of their male counterparts. The professional engineering bodies continue to struggle with this phenomenon but must also continue to investigate for themselves or fund appropriate research. Engaging females with engineering to the same extent as males could have a significant impact on the engineering skills shortage in New Zealand, because a higher proportion of females employed conveys the notion that engineering is an accepted and valued career for women.

Finally, but importantly, the lack of impact on career decisions perceived by students from the suggested sources of information is of concern. The analysis of their responses to other items within the questionnaire revealed that many students indicated they had taken little notice of any of the suggested sources of information. Consequently it seems clear that students need to be consulted about what they feel would be the most effective method of disseminating knowledge about engineering. Many students indicated that family had been significant in their career decision making, however most students did not have engineers in their family. This emphasizes the importance of finding out how best to design information programs for students which motivate them towards a future in engineering.

Concluding Comment

As the researcher was completing the writing of this thesis, an international newspaper published in the UK, The Telegraph (19-25 September, 2012), reported that Semta, which is the sector skills council for science, engineering and manufacturing technologies, predicted that an additional 82,000 scientists, engineers, and technologist would be needed in the UK by 2016, “simply to keep pace with the retirement of an aging workforce” (p. 32). For New Zealand to avoid a similar situation of impending deficit, it is critical that young minds are engaged with the fields of science, and particularly with the notion of careers in engineering. Although the sample surveyed for this research was not representative of the total student population in New Zealand schools, the findings related to the perceived status of engineers by Pākehā and Māori point to a possible issue involving 80% of the tertiary intake. Resolution of such an issue could have a significant impact on enrolment into engineering programs from students of those ethnic backgrounds, and a significant impact on the future development of New Zealand.

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Notes:

1. In addition to this list of references are 42 website references, placed as footnotes so as to be close to the text to which they related.
2. Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright owner who has been omitted or incorrectly acknowledged.

APPENDICES

Appendix A: The Letter for School Principals

School Address

Robert Craig (Professor)
Director, Information Technology
Ministry of Higher Education,
Sultanate of Oman
GSM: +968 95703213
Email: pdit@mohe.gov.om

Dear Principal/ Careers Advisor,

An investigation into career choice aimed at increasing
the enrolment of New Zealanders in Bachelor of Engineering courses

I need your assistance to conduct a survey of Year 12 school students in the Greater Auckland area. Your school has been chosen at random. To improve the validity of the results it is important that I maintain this randomness of selection.

You may also be contacted by *Robyn MacLeod*: *Women in Engineering Equity Advisor, University of Auckland* and/or *Angela Christie, Head of Schools Programme, IPENZ*

I apologise if you are bombarded with requests, however the results of this research could be of long term benefit to all New Zealanders.

The rationale for the study is that student enrolment in bachelor of engineering degrees has fallen steadily during the past decade whilst the requirement for graduate engineers has not fallen. A general shortage of engineers is reported by the Institution of Professional Engineers New Zealand (IPENZ) and is apparent from the skills shortage lists on the Department of Immigration Website for every major New Zealand city. Economic growth depends on a steady supply of scientists and engineers, so if New Zealand is to develop as a successful and knowledgeable society it is critical that interest in engineering be rekindled.

The migration from engineering mimics the typical situation of developed nations yet there is however an anomaly in New Zealand: unlike overseas, NZ students do not desert maths and physics, and NZ females complete Y13 maths and physics in greater numbers than males. Yet just like overseas, relatively few students choose to study engineering.

The central objective of the research is to better understand why New Zealand school leavers do, or do not, choose to study engineering. The questionnaire is designed to elicit information to help assess the students' knowledge about professional engineering, career expectations in general, expectations of engineering as a possible career, and who or what has influenced those attitudes and expectations. Gender, race and demographic information are requested but NOT the respondent's name.

Depending of the size of your school you are requested to survey up to 30 students (15 male and 15 female for a mixed school). My enrolment data indicates some of the schools chosen have less than 15 students, in this case please survey all the available Y12 students.

Please be advised that only your school type is overt. Your school name has been transposed to a number, and that number remains confidential.

The questionnaire will be online with a completion time of around 10 minutes. The students' responses are entirely anonymous and free from ethical implications. Again, to improve validity I would request that the survey be conducted in some controlled manner e.g. at the beginning of an ICT lesson. Below is the url for the questionnaire for your perusal. At an agreed time, once all is in place, I shall send you your school number and url to an identical questionnaire for your students. (a precaution to reduce spurious data entry)

url to preview: **http://www.surveyshare.com/survey/take/?sid=105253**
Password: pilot

I shall contact you in a week or so and I hope you will confirm your school's participation. I look forward to your support and shall be happy to answer any questions and supply you with the anonymous collated responses from your school and a copy of the final analysis if you so wish.

Kindest regards, *Robert* 19th April 2010

Contact details of those involved with this Curtin University research:

Professor Leonie Rennie PhD – Supervisor
Curtin University
Western Australia
Email: l.rennie@curtin.edu.au

Associate Professor Janet Davies PhD – Associate Supervisor
Senior Lecturer, Graduate School of Education (retired)
Palmerston North
Massey University, New Zealand
Email: jrdavies@paradise.net.nz

Appendix B: The Survey Information Sheet for School Principals and Respondents

Information sheet to accompany the following survey research being carried out by Robert Craig as part of the degree of Doctor of Education at Curtin University.

An investigation of career choice, aimed at increasing the enrolment of New Zealanders into Bachelor of Engineering courses

This study relates to student enrolment in Bachelor of Engineering degrees, an enrolment which has fallen during the past decade by around thirty percent. A general shortage of engineers is reported by the Institution of Professional Engineers New Zealand and is apparent from the skills shortage lists on the Department of Immigration Website for every major New Zealand city.

The central objective of the research is to better understand why New Zealand school leavers do, or do not, choose to study engineering. The questionnaire is designed to elicit information to help me assess the pupils' knowledge about professional engineering, career expectations in general, expectations of engineering as a possible career, and who or what has influenced those attitudes and expectations. Gender, race and demographic information will be requested but NOT YOUR NAME.

It is anticipated that the results of this work will provide information to guide the approach taken by professional engineering bodies when promoting engineering, curriculum designers at both the compulsory and post-compulsory levels, and to assist the course and career guidance offered by secondary schools.

The questionnaire completion time should be around 10 minutes, and the responses are entirely anonymous and free from ethical implications.

Please be advised that participation in the survey is entirely voluntary and that you have the right to withdraw and withhold your answers at any stage of the questionnaire proceedings.

Your voluntary participation will certainly be appreciated.

Kindest regards,

Appendix C: Copy of Electronic Questionnaire

Note. The following is the opening page of the questionnaire which was accessed through the url. The actual questionnaire which follows could only be accessed by inserting the correct password.

School Career Choice - NZ Engineering - live

Thank you for helping with this survey. This questionnaire should take about ten minutes of your time. It is completely anonymous so please answer the questions as accurately as you can. You have the right to withdraw from this survey process whenever you like. Your information will be used only for this research and publications arising from this research project. By submitting this questionnaire when you have finished, you are agreeing to your responses being used in this study.

Password: ____

School Career Choice - NZ Engineering – live

1) Please enter your school number - your teacher will tell you if appropriate.

____

2) Is your school part of a planned scheme to promote science and/or engineering? ... Your teacher will tell you if they are aware of the answer

- yes
- no
- don't know

Please tell us a little about yourself

3) Indicate whether you are male or female

- Male
- Female

4) Indicate the type of school where you study

- State - mixed gender
- Integrated/Private - mixed gender
- State - female only Y12
- State - male only Y12
- Integrated/Private - female only Y12
- Integrated/Private - male only Y12

5) Please indicate your ethnic background

- Caucasian
- Chinese
- Indian
- Māori
- Other Asian
- Other Polynesian
- Other

6) What generation are YOU in terms of arrival in New Zealand?

- [ ] You were born overseas
- [ ] You were born in New Zealand of immigrant parents
- [ ] Your parents were born in New Zealand
- [x] Your ancestry in New Zealand is longer than above

7) How much education have you experienced in New Zealand?

- [ ] No junior school and only a little of senior school
- [ ] No junior school but most/all of senior school
- [ ] A little of junior school and most/all of senior school
- [ ] Most/all of junior school and most /all of senior school

8) Would you consider the subjects you studied at school to be predominantly arts or science?

- [ ] arts
- [ ] sciences
- [ ] a balance of both arts and sciences

Now tell us about your knowledge of engineering

9) What do you guess is the approximate ratio of males:females working in engineering in New Zealand?

- M:F is 80:20
- M:F is 60:40
- M:F is 40:60
- M:F is 20:80

10) Please check every option below that you feel is correct

- Engineering courses are available at universities in New Zealand
- Engineering courses are available at other institutions in New Zealand
- Engineering courses are available online
- Engineering courses are available part time

11) With which of the following do you most agree?

- All engineers essentially study the same courses
- Engineering courses are either mechanical or electrical or civil
- Engineering can be studied in a wide variety of fields
- Engineering can be studied in a wide variety of fields and at undergraduate and post graduate levels

12) How much do you feel engineers contribute to the way society as a whole develops?

- [ ] not at all
- [ ] only a little
- [ ] quite a lot
- [ ] enormously

13) Do you think New Zealand needs more engineers?

- [ ] yes
- [ ] no
- [ ] no idea

14) Which of the following best describes what engineering graduates do at work?

- [x] repair cars when they break down
- [ ] design bridges, aeroplanes or electronic circuits
- [ ] drive heavy vehicles such as trains and cranes
- [ ] repair refrigerators, washing machines or air-conditioners

15) Do you think New Zealand engineering qualifications are recognised overseas?

- [ ] yes
- [ ] no
- [ ] don't know

Now tell us how your knowledge about engineering was gained

16) How many engineers do you know well?

- [ ] none
- [ ] 1 to 4
- [ ] 5 to 10
- [ ] more than 10

17) Do you have a parent or brother or sister who is an engineer?

- [ ] Yes
- [ ] No

18) Do you have any other relative who is an engineer?

- [ ] Yes
- [ ] No

19) Have you attended any public seminars/talks outside school on engineering as a career?

- [ ] Yes
- [ ] No

20) Have you read any publications on engineering as a career?

- [ ] Yes
- [ ] No

21) Was engineering discussed with you as part of school career advice?

- [ ] Yes
- [ ] No

22) Have you been on any official visits to engineering/industry sites?

- [ ] Yes
- [ ] No

23) Have you attended talks at your school by engineers/industrialists?

- [ ] Yes
- [ ] No

24) Are you aware of publicity promoting engineering as a career or field of study?

- [x] Yes
- [ ] No

25) Have you personally done research into engineering as a career or field of study?

- [ ] Yes
- [ ] No

Please indicate your feelings on the following statements about your future career, whatever your career might be.

26) I EXPECT a high salary from my career

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

27) I EXPECT high status from my career

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

28) I EXPECT relatively continuous employment

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

29) I EXPECT to be able to work internationally

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

30) I EXPECT my job to help my country

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

31) I hope to use computers frequently at work

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

32) It is important to have interesting colleagues

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

33) It is important to work as part of a team

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

34) I must find my work interesting

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

35) Are you considering Engineering as a possible career or field of study?

- Definitely yes
- Maybe
- Not at all

Even if your field will not be engineering, how do you feel about the following statements on engineering as a career?

36) Engineers are well paid

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

37) Engineers are highly thought of in society

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

38) Engineers often use computers at work

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

39) There are many job opportunities for engineers

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

40) Engineers are needed all over New Zealand

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

41) Engineers make things that help daily life

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

42) Engineers will help the development New Zealand

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

43) Engineers have high status in New Zealand society

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

44) A career in engineering would be interesting

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

45) Engineering requires better maths and physics than I am capable of

- Strongly Disagree
- Disagree
- Agree
- Strongly Agree

46) Do you feel that engineering as a career is likely to appeal to

- WOMEN MORE than men
- men and women equally
- MEN MORE than women

If you have never, ever considered engineering as a career or field of study then skip to Q55, otherwise please indicate how much the following have influenced your feelings (whether positively or negatively) towards engineering as a career or field of study.

47) parents and/or brother and/or sister

- [ ] not at all
- [ ] small extent
- [ ] some extent
- [ ] great extent

48) other relatives

- [ ] not at all
- [ ] small extent
- [ ] some extent
- [ ] great extent

49) friends

- [ ] not at all
- [ ] small extent
- [ ] some extent
- [ ] great extent

50) mentor/ personal guide

- [ ] not at all
- [ ] small extent
- [ ] some extent
- [ ] great extent

51) television

- [ ] not at all
- [ ] small extent
- [ ] some extent
- [ ] great extent

52) cinema

- [ ] not at all
- [ ] small extent
- [ ] some extent
- [ ] great extent

53) magazines/ newspapers

- [ ] not at all
- [ ] small extent
- [ ] some extent
- [ ] great extent

54) shopping for electrical equipment

- not at all
- small extent
- some extent
- great extent

55) personal research

- not at all
- small extent
- some extent
- great extent

56) Who do you feel is the MOST important person with whom you have discussed your career?

- No one
- Close family member
- Other relative
- Friend
- Mentor/ personal guide
- School careers advisor

57) Please indicate your likely major field of study

- Natural and physical sciences
- Engineering/Architecture/Technology
- Agriculture/environmental studies
- Health
- Education
- Commerce
- Society and culture
- Religion and philosophy
- Creative/performing arts
- Services

58) Please make any other brief comments regarding your career choice.

The end.

Thank you very much for your help. Please press "finish" to send your answers to the survey collection system: "SurveyShare"

Finish

Appendix D: Notes on Questionnaire

1. The term *Caucasian* was used in error in the questionnaire, the term which should have been used is *Pākehā* (see footnote 1, page 1). Pākehā is adopted in the reporting of the results and in the discussions within this thesis.
   The term Pākehā subsumes Caucasian.

2. The term *Other Polynesian* was used in error in the questionnaire, the term which should have been used is *Pasifika* (see footnote 32, page 29). *Pasifika* is adopted in the reporting of the results and in the discussions within this thesis.
   The term Pasifika includes Polynesians and also those from Micronesia and the Kiribati group of Pacific islands.

Appendix E: Responses Data from the Online Questionnaire

Q2 [sch2] Is school part of planned scheme to promote science / engineering

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	63	21.6	21.9	21.9
	No	150	51.4	52.1	74.0
	Don't know	75	25.7	26.0	100.0
	Total	288	98.6	100.0	
Missing	Skipped	4	1.4		
	Total	292	100.0		

Q3 [pers1] Gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	157	53.8	54.9	54.9
	Female	129	44.2	45.1	100.0
	Total	286	97.9	100.0	
Missing	Skipped	6	2.1		
	Total	292	100.0		

Q4 [pers2] Type of school

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	State - mixed gender	247	84.6	84.9	84.9
	Integrated / private - mixed gender	12	4.1	4.1	89.0
	State - female only Y13	12	4.1	4.1	93.1
	State - male only Y13	8	2.7	2.7	95.9
	Integrated / Private - female only Y13	4	1.4	1.4	97.3
	Integrated / Private - male only Y13	8	2.7	2.7	100.0
	Total	291	99.7	100.0	
Missing	Skipped	1	.3		
	Total	292	100.0		

Q5 [pers3] Ethnic background

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Caucasian	132	45.2	45.2	45.2
	Chinese	15	5.1	5.1	50.3
	Indian	20	6.8	6.8	57.2
	Māori	24	8.2	8.2	65.4
	Other Asian	19	6.5	6.5	71.9
	Other Polynesian	29	9.9	9.9	81.8
	Other	53	18.2	18.2	100.0
	Total	292	100.0	100.0	

Q6 [pers4] Generation in terms of arrival in NZ

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Born overseas	91	31.2	31.5	31.5
	Born in NZ of immigrant parents	48	16.4	16.6	48.1
	Parents born in NZ	91	31.2	31.5	79.6
	NZ ancestry longer than above	59	20.2	20.4	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q7 [pers5] Education in NZ

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No junior, only a little senior	15	5.1	5.1	5.1
	No junior, most / all of senior	16	5.5	5.5	10.6
	Little junior, most / all of senior	36	12.3	12.3	22.9
	Most / all of junior, most / all of senior	225	77.1	77.1	100.0
	Total	292	100.0	100.0	

Q8 [pers6]Subjects studied at school

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Predominantly arts	62	21.2	21.4	21.4
	Predominantly science	116	39.7	40.0	61.4
	Balance of arts and science	112	38.4	38.6	100.0
	Total	290	99.3	100.0	
Missing	Skipped	2	.7		
	Total	292	100.0		

Q9 [know1] Ratio of males : females working in engineering in NZ

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	80:20	162	55.5	56.3	56.3
	60:40	102	34.9	35.4	91.7
	40:60	14	4.8	4.9	96.5
	20:80	10	3.4	3.5	100.0
	Total	288	98.6	100.0	
Missing	Skipped	4	1.4		
	Total	292	100.0		

Q10 [know2] Availability of engineering courses

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	q10.1 Universities in NZ	250	85.6	100.0	100.0
Missing	System	42	14.4		
	Total	292	100.0		
Valid	q10.2 Other institutions in NZ	217	74.3	100.0	100.0
Missing	System	75	25.7		
	Total	292	100.0		
Valid	q10.3 Online	82	28.1	100.0	100.0
Missing	System	210	71.9		
	Total	292	100.0		
Valid	q10.4 Part time	129	44.2	100.0	100.0
Missing	System	163	55.8		
	Total	292	100.0		

Q11 [know3] Statement most agree with

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	All engineers study essentially same courses	23	7.9	8.0	8.0
	Engineering courses are mechanical / electrical / civil	67	22.9	23.3	31.4
	Engineering has wide variety of fields	98	33.6	34.1	65.5
	Engineering has variety of fields and levels	99	33.9	34.5	100.0
	Total	287	98.3	100.0	
Missing	Skipped	5	1.7		
	Total	292	100.0		

Q12 [know4] How engineers contribute to way society develops

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	8	2.7	2.8	2.8
	Only a little	33	11.3	11.4	14.2
	Quite a lot	165	56.5	57.1	71.3
	Enormously	83	28.4	28.7	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q13 [know5] NZ needs more engineers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	149	51.0	51.2	51.2
	No	24	8.2	8.2	59.5
	Don't know	118	40.4	40.5	100.0
	Total	291	99.7	100.0	
Missing	Skipped	1	.3		
	Total	292	100.0		

Q14 [know6] What engineering graduates do at work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Repair cars when they break down	59	20.2	20.4	20.4
	design bridges, airplanes & electronic circuits	206	70.5	71.3	91.7
	Drive heavy vehicles	8	2.7	2.8	94.5
	Repair fridges, washing machines or ACs	16	5.5	5.5	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q15 [know7] NZ engineering qualifications are recognised overseas

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	148	50.7	51.2	51.2
	No	45	15.4	15.6	66.8
	Don't know	96	32.9	33.2	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q16 [srce1] Number of engineers know well

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	None	118	40.4	40.5	40.5
	1-4	136	46.6	46.7	87.3
	5-10	23	7.9	7.9	95.2
	10+	14	4.8	4.8	100.0
	Total	291	99.7	100.0	
Missing	Skipped	1	.3		
	Total	292	100.0		

Q17 [srce2] Have parent / brother / sister who is an engineer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	232	79.5	79.5	79.5
	Yes	60	20.5	20.5	100.0
	Total	292	100.0	100.0	

Q18 [srce3] Have any other relative who is an engineer

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	168	57.5	57.5	57.5
	Yes	124	42.5	42.5	100.0
	Total	292	100.0	100.0	

Q19 [srce4] Attended public seminars / talks on engineering as a career

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	247	84.6	84.6	84.6
	Yes	45	15.4	15.4	100.0
	Total	292	100.0	100.0	

Q20 [srce5] Read any publications on engineering as a career

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	207	70.9	70.9	70.9
	Yes	85	29.1	29.1	100.0
	Total	292	100.0	100.0	

Q21 [srce6] Engineering discussed as part of school career advice

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	182	62.3	62.3	62.3
	Yes	110	37.7	37.7	100.0
	Total	292	100.0	100.0	

Q22 [srce7] Official visits to engineering / industry sites

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	239	81.8	81.8	81.8
	Yes	53	18.2	18.2	100.0
	Total	292	100.0	100.0	

Q23 [srce8] Attended talks at school by engineers / industrialists

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	260	89.0	89.0	89.0
	Yes	32	11.0	11.0	100.0
	Total	292	100.0	100.0	

Q24 [srce9] Aware of publicity promoting engineering as career

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	196	67.1	67.1	67.1
	Yes	96	32.9	32.9	100.0
	Total	292	100.0	100.0	

Q25 [srce10] Personally done research into engineering as career or field of study

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No	213	72.9	72.9	72.9
	Yes	79	27.1	27.1	100.0
	Total	292	100.0	100.0	

Q26 [crrgen1] Expect high salary from my career

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	1.4	1.4	1.4
	Disagree	39	13.4	13.5	14.9
	Agree	175	59.9	60.8	75.7
	Strongly agree	70	24.0	24.3	100.0
	Total	288	98.6	100.0	
Missing	No	4	1.4		
	Total	292	100.0		

Q27 [crrgen2] Expect high status from my career

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	8	2.7	2.8	2.8
	Disagree	65	22.3	22.4	25.2
	Agree	171	58.6	59.0	84.1
	Strongly agree	46	15.8	15.9	100.0
	Total	290	99.3	100.0	
Missing	Skipped	2	.7		
	Total	292	100.0		

Q28 [crrgen3] Expect relatively continuous employment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	1.4	1.4	1.4
	Disagree	29	9.9	10.0	11.4
	Agree	183	62.7	63.3	74.7
	Strongly agree	73	25.0	25.3	100.0
	Total	289	99.0	100.0	
Missing	No	3	1.0		
	Total	292	100.0		

Q29 [crrgen4] Expect to be able to work internationally

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	4	1.4	1.4	1.4
	Disagree	41	14.0	14.1	15.5
	Agree	171	58.6	59.0	74.5
	Strongly agree	74	25.3	25.5	100.0
	Total	290	99.3	100.0	
Missing	Skipped	2	.7		
	Total	292	100.0		

Q30 [crrgen5] Expect my job to help my country

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	12	4.1	4.2	4.2
	Disagree	68	23.3	23.6	27.8
	Agree	143	49.0	49.7	77.4
	Strongly agree	65	22.3	22.6	100.0
	Total	288	98.6	100.0	
Missing	Skipped	4	1.4		
	Total	292	100.0		

Q31 [crrgen6] Hope to use computers frequently at work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	16	5.5	5.5	5.5
	Disagree	74	25.3	25.6	31.1
	Agree	141	48.3	48.8	79.9
	Strongly agree	58	19.9	20.1	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q32 [crrgen7] Important to have interesting colleagues

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	6	2.1	2.1	2.1
	Disagree	27	9.2	9.3	11.4
	Agree	180	61.6	62.3	73.7
	Strongly agree	76	26.0	26.3	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q33 [crrgen8] Important to work as part of a team

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	5	1.7	1.7	1.7
	Disagree	30	10.3	10.4	12.1
	Agree	134	45.9	46.4	58.5
	Strongly agree	120	41.1	41.5	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q34 [crrgen9] Must find work interesting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	3	1.0	1.0	1.0
	Disagree	11	3.8	3.8	4.8
	Agree	94	32.2	32.3	37.1
	Strongly agree	183	62.7	62.9	100.0
	Total	291	99.7	100.0	
Missing	Skipped	1	.3		
	Total	292	100.0		

Q35 [crrgen10] Considering engineering as a career or field of study

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Definitely yes	38	13.0	13.1	13.1
	Maybe	117	40.1	40.5	53.6
	Not at all	134	45.9	46.4	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q36 [crreng1] Engineers are well paid

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	13	4.5	4.5	4.5
	Disagree	35	12.0	12.0	16.5
	Agree	197	67.5	67.7	84.2
	Strongly agree	46	15.8	15.8	100.0
	Total	291	99.7	100.0	
Missing	Skipped	1	.3		
	Total	292	100.0		

Q37 [crreng2] Engineers are highly thought of in society

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	14	4.8	4.9	4.9
	Disagree	93	31.8	32.3	37.2
	Agree	155	53.1	53.8	91.0
	Strongly agree	26	8.9	9.0	100.0
	Total	288	98.6	100.0	
Missing	Skipped	4	1.4		
	Total	292	100.0		

Q38 [crreng3] Engineers often use computers at work

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	10	3.4	3.5	3.5
	Disagree	79	27.1	27.3	30.8
	Agree	165	56.5	57.1	87.9
	Strongly agree	35	12.0	12.1	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q39 [crreng4] Many job opportunities for engineers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	12	4.1	4.1	4.1
	Disagree	49	16.8	16.9	21.0
	Agree	184	63.0	63.4	84.5
	Strongly agree	45	15.4	15.5	100.0
	Total	290	99.3	100.0	
Missing	Skipped	2	.7		
	Total	292	100.0		

Q40 [crreng5] Engineers are needed all over NZ

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	7	2.4	2.4	2.4
	Disagree	34	11.6	11.7	14.1
	Agree	176	60.3	60.7	74.8
	Strongly agree	73	25.0	25.2	100.0
	Total	290	99.3	100.0	
Missing	Skipped	2	.7		
	Total	292	100.0		

Q41 [crreng6] Engineers make things that help daily life

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	6	2.1	2.1	2.1
	Disagree	20	6.8	6.9	9.0
	Agree	177	60.6	61.0	70.0
	Strongly agree	87	29.8	30.0	100.0
	Total	290	99.3	100.0	
Missing	Skipped	2	.7		
	Total	292	100.0		

Q42 [crreng7] Engineers will help the development of NZ

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	10	3.4	3.5	3.5
	Disagree	19	6.5	6.6	10.0
	Agree	169	57.9	58.5	68.5
	Strongly agree	91	31.2	31.5	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q43 [crreng8] Engineers have high status in NZ

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	14	4.8	4.8	4.8
	Disagree	96	32.9	33.2	38.1
	Agree	156	53.4	54.0	92.0
	Strongly agree	23	7.9	8.0	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q44 [crreng9] A career in engineering would be interesting

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	30	10.3	10.3	10.3
	Disagree	56	19.2	19.2	29.6
	Agree	156	53.4	53.6	83.2
	Strongly agree	49	16.8	16.8	100.0
	Total	291	99.7	100.0	
Missing	Skipped	1	.3		
	Total	292	100.0		

Q45 [crreng10] Engineering requires better mathematics and physics

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Strongly disagree	19	6.5	6.6	6.6
	Disagree	77	26.4	26.7	33.3
	Agree	116	39.7	40.3	73.6
	Strongly agree	76	26.0	26.4	100.0
	Total	288	98.6	100.0	
Missing	Skipped	4	1.4		
	Total	292	100.0		

Q46 [crreng11] Engineering as a career will appeal to:

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Women more than men	6	2.1	2.1	2.1
	Men and women equally	68	23.3	23.5	25.6
	Men more than women	215	73.6	74.4	100.0
	Total	289	99.0	100.0	
Missing	Skipped	3	1.0		
	Total	292	100.0		

Q47 [infl1] Influenced by parents and / or siblings

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	59	20.2	34.7	34.7
	Small extent	51	17.5	30.0	64.7
	Some extent	44	15.1	25.9	90.6
	Great extent	16	5.5	9.4	100.0
	Total	170	58.2	100.0	
Missing	Skipped	122	41.8		
	Total	292	100.0		

Q48 [infl2] Influenced by other relatives

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	69	23.6	40.8	40.8
	Small extent	48	16.4	28.4	69.2
	Some extent	41	14.0	24.3	93.5
	Great extent	11	3.8	6.5	100.0
	Total	169	57.9	100.0	
Missing	Skipped	123	42.1		
	Total	292	100.0		

Q49 [infl3] Influenced by friends

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	78	26.7	46.2	46.2
	Small extent	45	15.4	26.6	72.8
	Some extent	34	11.6	20.1	92.9
	Great extent	12	4.1	7.1	100.0
	Total	169	57.9	100.0	
Missing	Skipped	123	42.1		
	Total	292	100.0		

Q50 [infl4] Influenced by mentor / personal guide

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	88	30.1	52.4	52.4
	Small extent	42	14.4	25.0	77.4
	Some extent	30	10.3	17.9	95.2
	Great extent	8	2.7	4.8	100.0
	Total	168	57.5	100.0	
Missing	Skipped	124	42.5		
	Total	292	100.0		

Q51 [infl5] Influenced by television

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	60	20.5	35.3	35.3
	Small extent	60	20.5	35.3	70.6
	Some extent	40	13.7	23.5	94.1
	Great extent	10	3.4	5.9	100.0
	Total	170	58.2	100.0	
Missing	Skipped	122	41.8		
	Total	292	100.0		

Q52 [infl6] Influenced by cinema

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	94	32.2	55.6	55.6
	Small extent	39	13.4	23.1	78.7
	Some extent	28	9.6	16.6	95.3
	Great extent	8	2.7	4.7	100.0
	Total	169	57.9	100.0	
Missing	Skipped	123	42.1		
	Total	292	100.0		

Q53 [infl7] Influenced by magazines / newspapers

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	74	25.3	43.8	43.8
	Small extent	46	15.8	27.2	71.0
	Some extent	41	14.0	24.3	95.3
	Great extent	8	2.7	4.7	100.0
	Total	169	57.9	100.0	
Missing	Skipped	123	42.1		
	Total	292	100.0		

Q54 [infl8] Influenced by shopping for electrical equipment

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	63	21.6	37.3	37.3
	Small extent	41	14.0	24.3	61.5
	Some extent	52	17.8	30.8	92.3
	Great extent	13	4.5	7.7	100.0
	Total	169	57.9	100.0	
Missing	Skipped	123	42.1		
	Total	292	100.0		

Q55 [infl9] Influenced by personal research

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Not at all	123	42.1	47.9	47.9
	Small extent	50	17.1	19.5	67.3
	Some extent	53	18.2	20.6	87.9
	Great extent	31	10.6	12.1	100.0
	Total	257	88.0	100.0	
Missing	Skipped	35	12.0		
	Total	292	100.0		

Q56 [infl10] Most important person with whom discussed career

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	No-one	39	13.4	13.4	13.4
	Close family member	155	53.1	53.4	66.9
	Other relative	12	4.1	4.1	71.0
	Friend	34	11.6	11.7	82.8
	Mentor / personal guide	11	3.8	3.8	86.6
	School careers advisor	39	13.4	13.4	100.0
	Total	290	99.3	100.0	
Missing	Skipped	2	.7		
	Total	292	100.0		

Q57 [field] Likely major field of study

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Natural and physical sciences	18	6.2	6.3	6.3
	Engineering / Architecture / Technology	90	30.8	31.5	37.8
	Agriculture / environmental studies	7	2.4	2.4	40.2
	Health	46	15.8	16.1	56.3
	Education	15	5.1	5.2	61.5
	Commerce	14	4.8	4.9	66.4
	Society and culture	14	4.8	4.9	71.3
	Religion and philosophy	1	.3	.3	71.7
	Creative / performing arts	50	17.1	17.5	89.2
	Services	31	10.6	10.8	100.0
	Total	286	97.9	100.0	
Missing	Skipped	6	2.1		
	Total	292	100.0		