

**INVESTIGATION OF THE CAUSAL FACTORS FOR ENROLLMENT
AND SATISFACTION IN ENGINEERING**

by

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A thesis submitted to the Department of Mechanical Engineering

In conformity with the requirements for
the degree of Master of Applied Science

Queen's University

Kingston, Ontario, Canada

(September, 2015)

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Abstract

Undergraduate students at Queen's University were surveyed and interviewed to examine the factors behind engineering program selection and academic transfer to engineering. The surveys were completed by 416 2nd-4th year undergraduate engineering students examining: reasons for entering engineering, demographics, personal knowledge of engineers, and their understanding of engineering programs and the engineering profession. The survey was also used to recruit students who had undergone an academic transfer for interview. Seven interviews were completed with these students, examining the reasons for their transfer, as well as the factors behind their initial program selection.

Four primary factors were identified as important to the selection of engineering programs: interest in the subject matter, strength in prerequisites, knowing an engineer, and vocational factors. It was found that knowing an engineer correlated with greater reported knowledge of the engineering profession, but *not* with a greater knowledge of engineering programs.

Small correlations were found between two survey variables and satisfaction: likelihood to continue on to an engineering profession and personal interest in subject matter. This presents 'personal interest' as a particularly valuable criterion for program selection.

Reasons that students transferred into engineering were split between a similarity of values with the program and practical reasons. Social/cultural values were discussed, suggesting that students valued engineering traditions and that engineering students were more social than expected. Students further identified academic values that they shared with the engineering program: co-operation and group work, practicality and problem solving. Understandings of these values were generally gained after they had entered Queen's, through peers already in the engineering program. Transfer students also addressed practical considerations: degree versatility, directness to workplace, personal change/growth, the engineering job market, and support from others.

Acknowledgements

Thank you to the many people who supported this project, as well as myself through this thesis and graduate program.

I would like to thank the participants who spent their time completing my survey, as well as the instructors who gave up their class time. I am especially grateful to those who consented to be interviewed, and hope they enjoyed the process as much as I did.

Thank you to the Faculty of Education for your patient instruction on research methods. Thank you to those in the department of Mechanical Engineering, who have been helpful for the past six years of schooling, and whose open-mindedness to engineering education research has helped make this degree go smoothly.

To my supervisor David Strong, thank you for your patience, your guidance, and your belief in me. I'm glad to have helped in your mission to enhance engineering education, and wish you the best of luck in your continued efforts.

To Myriam Beaulne, thank you for your effective critique, and your level-headed guidance throughout this project.

To Professors Don Klinger and Charles Molson, and my friend Randall Boyes, thank you for your time and advice on all things quantitative. Thank you to Chris Conway for gathering admissions statistics, which have proved vital to this project.

My eternal gratitude to Allison Chong, whose support was entirely essential to this achievement.

Thank you to the rest of our ‘engineering education group’ at Queen’s: David Waller, Scott Compeau, Richard Aleong, Dorothy Messingham and Jake Kaupp, without whom this journey would have been bland.

Thank you to Anne-Marie Bergman whose smile and understanding lit up even the darkest of days.

Thank you to my parents Will and Julia, and my sister Caitlin for your support. Finally, thank you to Cait Martin-Newnham for your encouragement this past year.

I couldn’t have done it without you all.

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Chapter 1

Introduction

Academic choices can have a profound impact on a person's life. In Ontario, students must attend primary school and continue through secondary school until 18 years of age (or graduation, should it come first). Students' educations first diverge when courses are separated by level starting in 9th grade. This distinction continues into university-, college- and workplace-level courses by the end of secondary school. Secondary school students also select from pools of elective courses such as arts, physical education, and advanced math and science. Upon graduation from secondary school, students have two main options: they can enter the workforce or pursue further education. Applications for university programs are accepted in January of students' final year at secondary school, so by that time, each student must have a plan for their educational path.

University-bound students must ensure that they acquire the prerequisite credits for each program to which they intend to apply. Prerequisites tend to be numerous for Science, Mathematics and Engineering (SME) programs, often necessitating several specific top-level courses. Engineering students across Ontario are required to complete one top-level course in each of English, Chemistry and Physics, and two in Mathematics [1]. The only one of these courses is required to complete the Ontario Secondary Schools Diploma is English, although only workplace-level English is required. Students may decline to take Mathematics after Grade 11 and Science after Grade 10, and still qualify for a diploma [1]. Hence, course selection as early as Grade 10 directly affects the ability to apply to University SME programs. In Ontario, students are instructed on career options through a half-semester course in Grade 10 [1]. The existence of this course reflects the understanding that an early knowledge of career direction can impact the academic path of a student, despite the fact that it occurs after academic path divergence.

Many factors may be important in establishing one's career direction but the universal first step is a basic understanding of one's chosen profession. Some careers can be defined in simple terms, making it easier for a young person to digest. "A mechanic fixes cars", is an example of this concept. While it may not give a complete picture of what a mechanic does, it is useful in establishing a young person's basic understanding. Another important factor is exposure through visibility. There are three ways that young people have exposure to professions: through direct or indirect use of their services (e.g. doctors, dentists, pharmacists, librarians, teachers, drivers, plumbers and mechanics), through prominence in media and society (e.g. politicians, athletes, lawyers, artists, executives). Engineers fail to meet either of these criteria, because most engineering work is done 'behind the scenes', designing and enhancing end-products for others to use. As a result, the engineering profession has a relative lack of practical visibility with young people, compared to many other career paths.

1.1 Choosing Engineering

Despite the low visibility of engineering, many students choose to enter engineering programs. Students select programs based on a marriage of their perceptions of their program options and following careers; their perceptions of their own interests and strengths; and a host of external influences. Of course, each of these broader factors are based upon the myriad of influences and information gathered by a student up until that time.

Pearson (2012) built a model to predict the likelihood of selecting engineering based on specific factors, including those discussed below.

- **Planning to be an engineer:** although self-evident, students who planned to enter engineering while in high school were much more likely to do so [2]
- **Parental push in math and science:** push from parents in engineering precursor subjects increased the likelihood of entry [2]
- **Gender:** males were more likely to select engineering [2], [3]
- **Family:** Having parents or relatives in engineering increased likelihood of enrollment [3]

- **Expected earnings:** students were more likely to select majors after which they expected to make more money, regardless of the validity of that expectation [4]
- **Perception comparative strength in field:** Students were more likely to choose a given program if they expected to be comparatively strong in that program [4].

These factors are not exclusive nor agreed upon, and compelled this study's first research question: "What causes students to select engineering?"

1.2 Retention at Engineering Schools

Historically, many students who have entered engineering programs either transfer out of the program or fail to complete their degree. Student retention is widely studied in engineering, due to a near 50% retention rate across engineering programs, as recorded in the US in 1992 [3]. Ohland (2008) suggests a more current retention rate of "nearly 60%" through analysis of the longitudinal MIDFIELD survey [5]. The graduation rate of the engineering cohort of 2002 across Ontario was 78.9%, lower than most other programs, which can be seen below in Figure 1 [6]. Graduation rate is measured as the percentage of students who had graduated 7 years after program entry. This higher graduation/retention rate can be seen in Canada, in comparison with the US, and is likely a function of less variable program quality in Canadian institutions, as well as generally lower tuition costs.

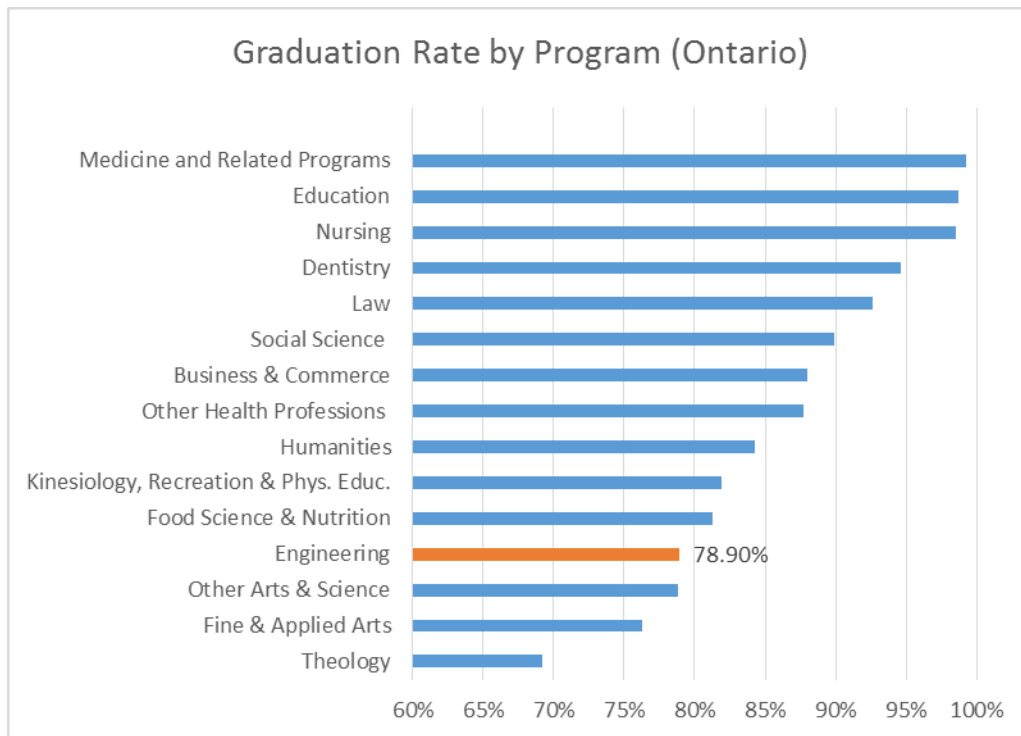


Figure 1: Graduation Rate in Ontario by Program (2002 Cohort) [6]

There are two primary reasons why students leave engineering programs, as identified in Chapter 2: academic difficulty and lack of fit. Both of these factors imply an initial lack of information or understanding of the engineering program. This exodus from engineering programs is problematic, especially for engineering students. There is a large cost to students in terms of time and money. In most cases, either by transferring from the program, or by leaving university altogether, students squander their engineering credits. Faculties are also affected, in that they must proportionally reduce their upper year class sizes. Industry is affected, as fewer engineering graduates are making their way to the workplace. A strong predictor of retention is satisfaction [7], and for this reason, satisfaction can be used as a measurement of success in program selection. This lead to a second research question: “What relationship do program selection factors have with program satisfaction?”

1.3 Queen's University

Queen's University is a public research and educational institution in Kingston, Ontario, with an undergraduate student population of about 16 000 [8]. The Faculty of Engineering and Applied Science at Queen's is relatively large, with approximately 3000 students over four years [9]. Queen's Engineering is a well-known program and has long-standing traditions, especially related to Orientation Week and Homecoming activities. This leads to generally positive associations and a high profile on campus. Academically, Queen's Engineering is not a typical engineering program, due to four substantial deviations from other engineering institutions in Ontario.

1.3.1 Obligatory Common First Year

All engineering students at Queen's enter into a common first year, before they select their discipline prior to second year. This first year has a wide variety of courses, including graphics and geology, which would only otherwise be taken by certain disciplines. This provides students exposure to subject matter they may not have seen otherwise, and can ostensibly allow students to select a better-fitting discipline. Students are introduced to the specific disciplines late in their first year through class discussion and open house nights, as well as through elective discussion with their instructors. This allows students to have an understanding of each discipline before they commit to one. Few other universities in Ontario offer common first year programming; most schools require students to enter disciplines upon application.

1.3.2 Guaranteed Discipline Selection

After completion of the open first year, engineering students at Queen's are guaranteed entry into the discipline of their choice, restricted only by their successful completion of first year courses. Students who do poorly in certain courses, but still complete their first year are restricted to disciplines without significant reliance on the failed course.

1.3.3 Availability of Atypical Disciplines

Queen's University offers five atypical disciplines which are especially unique: Geological Engineering, Mining Engineering, Engineering Chemistry, Math and Engineering, and Engineering Physics.

Geological Engineering and Mining Engineering have a reduced level of reliance on theoretical physics and mathematics, which provides a potential direction for students with reduced interest and/or aptitude in those subjects. Engineering Chemistry, Math and Engineering, and Engineering Physics follow the opposite path, relying more heavily on theoretical math and science, although still through application.

1.3.4 Remedial First Year Session (J-Section)

Students who have academic difficulty in their first semester of first year have the option to retake up to five core courses in a remedial semester from January-February, after which they continue second semester into the summer to catch up to their cohort. This is called J-Section, and was instituted in the early 1970s [10]. This session allows further retention of students who may otherwise have left the program after first year.

1.3.5 High Entrance Averages

The Queen's Engineering program generally has a high entrance average, although it fluctuates by year. In 2013-2014, the entrance cutoff was at approximately 84%, qualifying each student as an Ontario Scholar (80%+) [9]. This cutoff is among the highest at any Canadian engineering school, which likely raises students' chance of academic success.

1.3.6 Higher Retention Rate

It is believed that this combination of differentiating factors increase the Queen's Engineering student retention rate, which at 89.6%, is significantly higher than the Ontario average of 76% [6], and vastly higher than rates drawn from literature of ~50% (in the US) [3]. A comparison can be seen below in Figure 2.

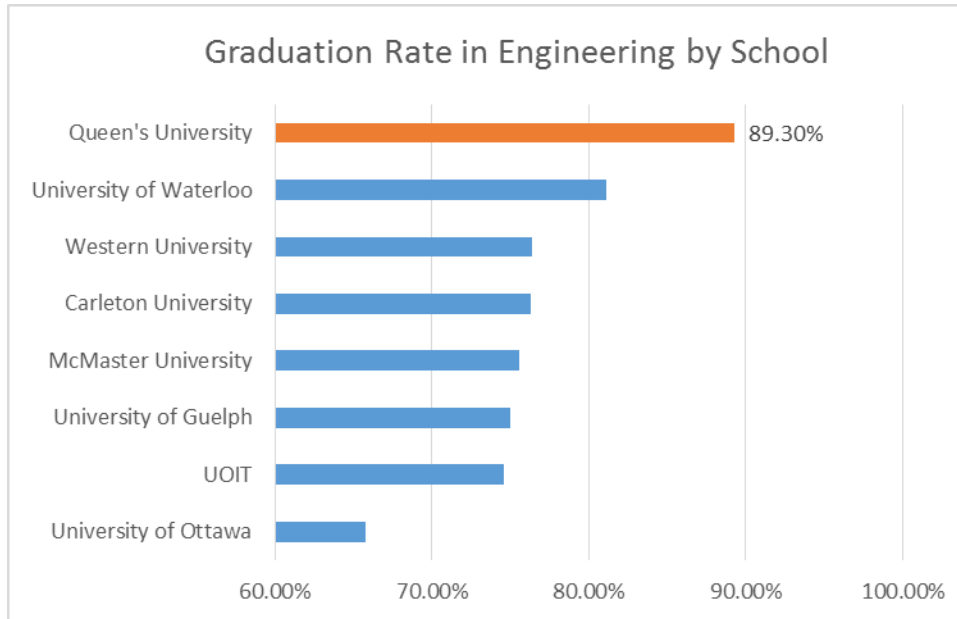


Figure 2: Graduation rate in engineering programs by institution [6]

All survey and interview data to be presented later in this paper were collected from undergraduate students in the Faculty of Engineering and Applied Science at Queen’s University. This leads to inherent bias, but serves to provide an in-depth understanding of phenomena present in this specific population.

1.4 Academic Transfer into Engineering

Few students tend to transfer into engineering programs during their undergraduate degree. The conventional reasoning attributed to this fact is that engineering programs have heavy prerequisite requirements, which increases the relative cost of transfer. Students who transfer into engineering are an exceptionally valuable population to study for five reasons:

- They can reflect on their fit in another program, as well as engineering.
- They represent a population of students who qualified to select engineering out of secondary school, but did not.
- This reasoning changed, and their transfer decision was based on recent reflection.
- They are generally high achievers [3], who are likely to succeed in engineering programs

- There is little research on this population to date.

These students were specifically targeted for interviews, and added a better-targeted research question: “Why do students transfer into engineering from other programs, and what lead them to their initial non-engineering selection?”

1.4.1 Engineering-Related Academic Transfer at Queen’s University

Distinctly more students transfer into than out of the engineering program at Queen’s. Numbers of students transferring into and out of engineering were found by comparing enrollment lists in various years, below in Table 1. For example, the first data pair was generated by counting the number of students who were enrolled in a Queen’s non-engineering program in 2011, and then a Queen’s engineering program in 2012. This did not include students who left Queen’s entirely, or entered Queen’s, even from another institution [11].

Table 1: Academic transfers into and out of engineering, 2011-2014 [11]

Academic Years	Academic Transfers	
	Into Eng.	Out of Eng.
2011-2012	21	2
2012-2013	11	2
2013-2014	26	4

This shows distinctly separate ranges between transfers into and out of engineering. Possible reasoning for this differentiation, suggested by a First Year Program Associate in the Engineering Office, was that in that most students who attempt to leave engineering do so because of poor academic standing, which makes it extremely difficult to enter other faculties [12]. This observation was supported by Astin and Astin (1992), which suggests that on average, those who transfer into engineering are the strongest academically, followed by those who selected engineering initially and continued, while those who leave engineering are generally the weakest academically [3].

The transfer process between programs at Queen’s are dictated by the policies and process of the students’ ‘destination’ program. The number of transfers allowed into the engineering program is

primarily influenced by the supply of available spots in each discipline [12]. This availability of spots is dictated by the proportion of students in the given cohort who selected that discipline, as well as by retention of students in that discipline [12]. Students who are deemed best qualified by the faculty are selected until each faculty has reached its capacity. Due to this supply-based methodology, students require anywhere between an A-average and C-average to successfully transfer, depending on their selected discipline [12]. Some students simply re-apply to the engineering program through the Ontario Universities' Application Centre (OUAC) as if they had just completed secondary school, to avoid this process, but in this case, they must start in first year [12].

1.5 Purpose of Study

There are two separate purposes for this study:

- To explore the reasons why students select engineering programs, and which of these reasons lead to satisfaction with their selection
- To explore the reasons why students transfer into engineering, and why they did not select engineering initially

A large focus of literature in engineering education is on student retention, and this concept is less important where retention is higher, but the need remains to understand why students select engineering programs, with the goal of recruiting students who are successful in and satisfied by the engineering program. This shift from an institutional perspective to a perspective personal to students represents a significant shift from the literature, to be discussed in Section 2.5.

This study further theorizes that students who transfer into engineering from other programs represent inefficiency in the recruitment system, in that these students, who have proven success in the engineering program, failed to select engineering upon application to university.

1.6 Study Philosophy

Since few studies have been done on reasons for entry to engineering programs, it was important for this study to identify phenomena yet to be documented. For this reason, this study was designed to be *exploratory*: attempting to capture phenomena that have been documented, that are suspected, and that are unexpected.

The study also accepted its primary limitation in its infancy, in that all data gathering was to be done at Queen's University. This allowed for greater research focus within the limits of researcher time, while positioning this study as a pilot, ideally allowing the roll-out of a similar, more focused study in the future. Since this study is the first of its kind in Canada, it also functions as a starting point for further research in this field.

Although it would be remedied by participation at other universities, the theoretical transferability of this study is limited, and special care should be taken when applying findings to other engineering student populations, especially given the uniqueness of the Queen's Engineering program, as discussed in Section 1.3. In studying this unconventional program, this thesis also performs the role of a case study.

Race/cultural background and socio-economic status were intentionally excluded from the scope of the study, with the intention of identifying general trends, not trends specific to participants' backgrounds.

Chapter 2

Literature Review

Little research has been done on students' reasons for, and satisfaction with, selecting engineering. To develop a framework with which to examine the principles involved, theory must be referenced from indirectly related academic pursuits. A prevalent and similar research subject is engineering program retention, so the majority of sources originate from that perspective.

2.1 Program/Major Selection

“Major Selection” is commonly used in the literature when discussing a student's choice entering university. This study will instead use “program selection”, as “major” is not generally used when describing engineering programs in Ontario.

As discussed in the Introduction, students who elect to enter university apply to programs in January, and select their program by May of their final semester in secondary school. Seymour (1997), summarized by Matusovich (2010), indicated that students select engineering based on a variety of factors including: program interest; the influence of family members, teachers and others; financial reasons; and success in high school math and science [13]. Seymour (1997) found that program interest correlated with retention, while the other factors studied did not [13].

Pearson (2012) built a structural equation model (SEM) to predict the likelihood of employment in engineering for participants who are now 34-37 years old, using data from the Longitudinal Study of American Youth (LSAY) [2]. The LSAY surveys students on their interest toward achievement in maths and sciences, starting in Grade 7 (~12 years of age) [2]. The SEM generated “total effect” measures for each variable, reflecting their relative strength in predicting an engineering career path [2]. Mathematics were shown to be important early indicators:

“Early enrollment in algebra provided an initial advantage (total effect = 0.15), which was linked with a positive student attitude toward mathematics (0.12) and higher levels of achievement in subsequent mathematics courses (0.14). The result of this sequence is the completion of a calculus course in high school, which had a total effect of 0.43” [2]

This effect of mathematics culminated with the completion of a calculus course in high school (0.43) [2]. Further, *“The total effect of planning to enter engineering (0.74) illustrates the importance of early career decisions on subsequent enrollment decisions and behaviors.” [2]* Employment of parents in STEM fields was shown to have limited predictive power to predict engineering enrollment (0.05) [2].

Astin & Astin (1992) has contrasting findings, indicating that having a father in engineering significantly increases the chance of selecting engineering [3]. Also reported to increase likelihood of engineering selection are: self-reported mathematical ability, strong scientific orientation, secondary school grades, and Asian-American ethnicity [3].

2.2 Student Fit

A student’s fit is determined by the interaction between personal characteristics (e.g. interests, values, beliefs, attitude and learning style) and institutional characteristics (e.g. culture, academic methodology, size and faculty) [14]. Fit has a distinct impact on program satisfaction, and this is discussed below, but there is little evidence that students actively predict their institutional fit in a given program before applying.

Schertzer & Schertzer (2004) breaks this relationship down into two parts: Student-Institution Congruency (Institutional Fit) and Student-Faculty Congruency (Academic Fit) [7].

2.2.1 Academic Fit

Academic fit has also been shown to have a close relationship with student satisfaction. Elliot & Shin (2002) suggest that a close correlation between preferred and actual classroom environments enhances student outcomes including satisfaction [15]. For example, a student who prefers learning through practical application will be more satisfied in a classroom where practical approaches are embedded into

teaching and evaluation [15]. Differences in teaching and learning methods are inevitable across program types, given the vastly different end-goals of programs. Engineering programs tend to teach and evaluate students through problem-solving, while Art History programs, for example, focus more heavily on knowledge transfer. This closely reflects the fundamental differences in expectations for an Engineer (analysis, examination and design), and an Art Historian (knowledge, recognition and interpretation). These and similar academic ‘values’ came up in the qualitative analysis, and are further discussed in Sections 5.2.3 and 6.1.3.1.

2.2.2 Institutional Fit

Schertzer & Schertzer (2004) borrows from Pervin (1968) to best describe institutional fit:

“...for each individual there are environments (interpersonal and non-interpersonal) which more or less match the characteristics of his (or her) personality. A “match” or “best-fit” of individual to environment is viewed as expressing itself in high performance, satisfaction, and little stress in the system whereas a “lack of fit” is viewed as resulting in decreased performance, dissatisfaction, and stress in the system.” [7]

For example, a student who highly values community might prefer a small campus with more pervasive culture than a student who more highly values privacy and anonymity. Universities attempt to portray their institutional attributes through various conduits, such as campus tours and promotional materials. Although limited by their promotional nature, students may attempt to gain a sense of campus culture, academic traditions and presence of faculty. This information is also gained from past and current students, creating a feedback loop with student satisfaction. Reciprocally, Elliott & Shin (2002) identifies universities as responsible to *“identify and deliver what is important to students”*, which ideally initiates evolution of university values over time [15].

2.3 Student Satisfaction

As described by Oliver (1989), “Student satisfaction refers to the favorability of a student’s subjective evaluation of the various outcomes and experiences associated with education.” [16] Student satisfaction is driven by the various factors that make up student experience. Elliot & Shin (2002) suggest: “*Student satisfaction is being shaped continually by repeated experiences in campus life. Moreover, the campus environment is seemingly a web of interconnected experiences that overlap and influence students’ overall satisfaction.*” [15]

Satisfaction can further be linked to ones perception of personal fit. Elliott & Shin (2002) interprets Borden (1995) in saying, “*...student satisfaction is related to the match between student priorities and the campus environment.*” [15]

Satisfaction is an important measure for university success, as well as student well-being. According to Elliot and Shin (2002), “*...studies have shown student satisfaction to have a positive impact on student motivation, student retention, recruiting efforts and fundraising.*” [15] The mechanism for this is theorized in Mustafa (2012): “*Satisfied and loyal customers can be very good and influential agents of promotion. They have the potential of being persuasive thus promoting the service they received...*” [17]

This perspective of students as customers of their university is imperfect, but valuable. The main difference is that when a student graduates, they are unlikely to return as a student, but may continue to help the university by suggesting it to others and by donation [17].

2.4 Program Retention/Attrition

Retention is defined as the proportion of students who enter into a program that complete that degree.

Some (especially older) studies also use the term ‘attrition’, referring instead to the proportion of students who leave a program prior to graduation.

Engineering programs have historically had a very low retention rate, 48% as reported by Astin & Astin in 1992, across American universities (n = 1542) [3]. This has compelled study in the field, especially by

connecting student behavior with their academic indicators [7], [18]–[20]. These studies have found that real and perceived strength in mathematics is a highly important academic factor in retention. Takahira (1998) asserts: “*Students [with higher GPAs and SAT-math scores] explained their departure in terms of their shifting career goals and the competitive, stressful environment of engineering programs.*” [18], and that “*it [is] important to conduct additional studies to further explore the meaning of the connection between grades, SAT scores, and persistence because different explanations imply different forms of intervention.*” [18] This is an important viewpoint, as a reminder that although students with poorer academic performance are obviously more vulnerable to attrition, there are further phenomena involved in their decision. In Queen’s Engineering, first year students with poor academic performance are allowed a second chance to complete their courses through J-Section, as discussed in Section 1.3.4 potentially retaining them, despite their vulnerable state.

Retention is especially important from the perspective of students. From Levine & Wyckoff (1990): “*For the students involved in this attrition, there is a costly and time consuming consequence which is often accompanied by emotional stress both for students and their families.*” [21]

Matusovich (2010) further comments, using the term ‘persistence’, which refers those who stay in engineering, to reflect its student-based perspective: “*Surprisingly little existing research on persistence in engineering has been conducted from the student perspective, and even less research explains how persistence happens.*” [13]

Marra & Rodgers (2012) conducted a factor analysis on students who left a single engineering program, and found that there were three distinct factors involved in their attrition: poor teaching and advising, the difficulty level of the engineering curriculum, and a lack of belonging in engineering [20]. Of these factors, the first is institutional and has little relevance to the student perspective, while the latter two relate directly to the concept of fit; in this case, academic fit and institutional fit respectively.

2.5 Fit in the Literature

As discussed in greater detail in Section 3.2, this study was composed of two interconnected parts. Part A consisted of a survey conducted with the general population of engineering undergraduates at Queen's. Part B consisted of interviews, primarily with students who had transferred into the engineering program from another faculty. Together, these parts form a Mixed Methods study.

No Mixed Methods studies were found that linked directly to this study. Instead, Parts A and B of this study individually relate much more closely to other studies. None of the related studies were performed in Canada.

2.5.1 Fit of Part A in the Literature

Sheppard (2010) is the prior study most closely related to Part A, but it was introduced late in the research process, so it was not involved in the study design or analysis [22]. It will be addressed at the end of this section to preserve the connections between the other studies, which were gathered initially.

Prior to the knowledge of Sheppard (2010), Pearson (2012) was considered to be the most closely linked to Part A [2]. Pearson (2012) used survey data from the Longitudinal Study of American Youth (LSAY) to run statistical modelling, determining which factors were important to the selection of engineering [2]. LSAY tracked students from Grades 7 and 8, through adulthood [2]. Part A lacked a large data set like LSAY, or the ability to record longitudinal observations, but had a comparative advantage in being able to 'know' the program selection path of participants retrospectively. Although Pearson had a large sample size ($n=3\ 539$), only 5% of these participants ended up enrolling in engineering programs [2].

Arcidiacono (2010) was not focused on engineering program selection specifically, but major selection overall [4]. It asked students to assess their own ability across a variety of fields, their preferences of field, and their expected earning in each field [4]. These were used to determine the relative importance of each factor, and the effect of 'forecast errors' in expected salary on selection of field [4]. This financial perspective was not a focus of Part A, but as indicated in Section 4.2.1, vocational—and likely financial—motivations were indicated by participants.

Jurkowitsch (2006) was published in the Journal of Innovative Marketing, on Austrian engineering schools [23]. This study provided value in offering a theoretical model for the progression of a student along their educational path, as seen below in Figure 3.

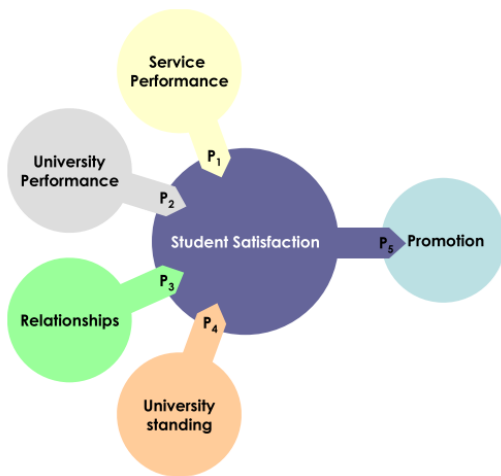


Figure 3: Satisfaction/Promotion Model from Jurkowitsch (2006) [23]

This layout of concepts was a helpful starting point for establishing a flowchart-style model later, as discussed in Section 0, which applies ‘Fit’ as the primary input for ‘Satisfaction’, and adds two more concepts. The methods employed by Jurkowitsch (2006) were heavily based on concepts of marketing, with the focus of recruitment of students [23].

As detailed at the beginning of this section, Sheppard (2010) shares many concepts with Part A, and likely would have heavily influenced the design of Part A, had it been located during the initial literature review [22]. It is based on the data from the Academic Pathways of People Learning Engineering Survey (APPLES), administered to students at 21 engineering colleges across the USA in 2008 (n=4200) [22].

Themes that Sheppard (2010) analyzes and discusses include: student demographics, academic experiences, motivations to study engineering, confidence in academics and post-graduation plans [22].

Each of these themes identify closely with the questions asked in Part A.

Simply by being conducted in Canada, this study helps fill gaps in the literature. It was also focused on engineering students, which separates it from Pearson (2012), and Jurkowsch (2006).

2.5.2 Fit of Part B in the Literature

Walden (2008) is the most closely related study to Part B, in that it studied a unique academic situation, and in that it preferentially interviewed transfer students [24]. This program is unique in that it has a female undergraduate enrollment rate of 58% [24]. 52 students were interviewed, 24 of whom had relocated into the School of Industrial Engineering at the University of Oklahoma [24]. Unlike Part B, 20 of the 24 students who had transferred, came from other disciplines in the school of engineering [24].

Matusovich (2010) conducted interviews with engineering students to examine why they chose engineering. Matusovich (2010) used 'values' as a factor in student retention, directly relating student ideals and behaviours to Eccles' Expectancy-Value Theory [13], [25]. These values, as identified by Eccles (2005), are 'Attainment', 'Cost', 'Interest' and 'Utility'. In Part B, values were instead extracted directly from the data using open coding. Matusovich (2010) was also able to perform longitudinal interviews, while Part B interviews were all done in one round.

Although Part B has cursory similarities with both Walden (2008) and Matusovich (2010), it is different in its focus on student transfer between faculties, and its use of open coding during the qualitative analysis.

2.6 Theoretical Model

Throughout the literature review, it became apparent that there were innate linkages between the concepts involved. A chronological model was used to help organize this section, and can be seen below in Figure 4 in the form of a flowchart.



Figure 4: Chronological Model from Information Gathering to Retention

This flowchart represents a chronology of events that each university student goes through during their educational career, each step influencing the next.

The process starts with **Information Gathering** that students undertake actively and/or passively, throughout their elementary and secondary school careers. This includes formal career education, information and opinions gathered through personal relationships, and personal investigation of universities and programs. From this information, students make **Program Selection** decisions, applying to and entering a chosen program at the university they select. Their **Fit in the Program** is then passively determined, based on their experiences at university [7]. This fit is based on the congruence of the features of the program and institution with those of the individual [14]. Fit within a program is then linked to **Satisfaction** [15], [23]. Students with greater reported satisfaction in turn have a higher rate of **Retention** [7].

This model helped put the process in perspective, and provided a framework for further analysis.

Although it is based in the literature, and reflects a logical progression, this framework was evaluated for efficacy, as will be discussed later in Section 6.3.

Chapter 3

Research Design

3.1 Objective, Research Questions and Overview

The objective of this study was to investigate the principles that govern student selection of engineering programs. The objectives were broken down into three research questions:

- 1) What factors cause students to select engineering?
- 2) What relationship do these factors have with program satisfaction?
- 3) Why do students transfer into engineering from other programs, and what led them to their initial non-engineering selection?

Although the factors involved in program selection, by definition, must be present prior to selection decisions, perspective was gained through the knowledge of each participants' *actual* selection, as well as their retrospective thoughts on the process. To answer the research questions, it was necessary to investigate two different populations: students who initially selected engineering and students who transferred into engineering later. To a university-based researcher with an ethically-sound study, undergraduate students are a valuably plentiful resource. In order to efficiently capture a large sample size, a survey was used to answer Research Questions 1 and 2. This survey portion of the study will be referred to as Part A. Part A was capable of capturing some information from students who transferred into engineering regarding Question 3, but the pool of transfer students is relatively small. This necessitated interviews with transfer students, which will be referred to as Part B. These interviews were valuable for contextualizing the survey data and allowing for a deeper understanding of the phenomena and processes involved.

3.2 Theoretical Framework

Creswell (2014) establishes that combined usage of quantitative and qualitative methodology can be referred to as Mixed Methods [26]. Creswell (2014) further discusses that distinct mixed methods designs are primarily defined by the chronology of data collection and the chosen methods of data merging, connection or embedding [26]. The use of Mixed Methods is inherently a pragmatic practice. Although it is naturally simpler to compare and reconcile data of the same type, the use of Mixed Methods represents a concession that neither quantitative nor qualitative methodology can properly capture *all* of the pertinent data. Instead it recognizes that different portions of data are better captured by different methods. In the context of this study, this refers to the benefits of quantitative methods for capturing the large sample of undergraduate engineering students, and simultaneously, the benefits of capturing the smaller sample of transfer students in greater depth.

This study follows the Explanatory Sequential Mixed Methods design [26]. In this design, Creswell (2014) identifies that data is collected sequentially – first quantitative, where a broad understanding is developed, then qualitative, which is built directly on the quantitative [26]. In most Explanatory Sequential designs, the sample population for qualitative study is determined reactively, based on quantitative results, however in this study, transfer students were already theorized to offer especially deep insight, and were pre-selected for qualitative analysis [26].

A non-experimental (no intervention), cross-sectional (one round of surveying across academic years) design was selected for the quantitative section, Part A. A survey was selected as the research instrument, to be administered once to the sample. To analyze the survey, descriptive statistics and correlation were selected for simplicity and robustness. More intensive analyses were investigated, but based on further review and expert opinion, validity was determined to be questionable. This process will be discussed in Section 4.3.1.

A Phenomenological research design was selected for the qualitative portion, Part B. Phenomenology refers to the practice of extracting an understanding of how people experience given phenomena, directly

from those people [27]. Part B also borrows from Grounded Theory in aiming to “*build theory rather than test theory*”, which aligns closely with the explorative philosophy of this study as a whole [27].

Semi-structured interviews were selected as the method for data collection due to their common use in the field, as well as their accessibility to a novice qualitative researcher. Basic coding was used to analyze the data. Themes were extracted from the data and summarized into theory.

3.3 Participant Selection

3.3.1 Participant Selection for Part A

As of 2014, the Faculty of Engineering and Applied Science at Queen’s University had an undergraduate population of 2 694 [9]. This population is spread over 4 academic years and 10 engineering disciplines [9]. In order to ensure participants had a developed perspective of their satisfaction in engineering, and some understanding of the engineering program, first-year students excluded as potential participants.

The purpose of Part A was to generate a high-breadth examination of students’ reasons for entering engineering and their ensuing satisfaction. None of the methods available to the researcher allowed for directed collection from specific individuals – students would ultimately be free to choose whether they answered the survey or not. With this restraints, stratified convenience sampling [26] was selected as the most reasonable methodology for gathering data from as many students as possible, while ensuring a variety of student demographics by year and discipline.

A common approach for survey roll-out is via cold email whereby the entire student population is introduced to the study premise and asked to participate. To increase the sample size, and to ensure participation by each year and discipline, the researcher instead entered a variety of classrooms and introduced the study and survey personally. This also worked to increase the visibility of the study and mitigated the expenditure of students’ time for participation, because time was allowed during the class specifically to complete the survey.

This study’s role as a pilot study will work to enable a possible broader roll-out to other engineering schools in the future.

3.3.2 Participant Selection for Part B

As discussed in Section 3.2, students who transferring into engineering were intentionally selected for participation in Part B. Patton (2001) classifies this methodology as Deviant Case Sampling, and distinguishes this technique where participants are selected based upon “*what cases [the research] could learn the most from*” [27]. This group of ‘transfer-ins’ are a prime example of students who likely could have initially chosen engineering, but did not, as described in further detail in Section 1.4.

These students represented a small portion of engineering undergraduates at Queen’s, and were difficult to track directly, due to privacy protections. Creswell (2014) provides a clue as to how this population should be found, in suggesting that in Explanatory Sequential Mixed Methods designs, the qualitative sample should ideally be selected from participants in the quantitative portion [26]. Following this direction, at the end of the Part A survey, participants were asked if they would consent to a follow-up interview, and Part B participants were selected from the transfer-ins in this pool. These selections were done purposefully, with an intent to vary by gender and discipline. Interviews were also conducted with one student who entered engineering directly, and another who only underwent transfer between engineering *disciplines*, in order to explore different participants groups.

3.4 Ethical Considerations

Before research could be conducted on human subjects, approval by the General Research Ethics Board (GREB) was obtained. All participants in this study were adults, and due to the lack of intervention of any kind, potential risk to participants was minimal. Three specific provisions were undertaken to ensure privacy: data was stored on locked devices, Part A participants were referred to only by reference number, and Part B participants were referred to only by randomly-assigned pseudonyms.

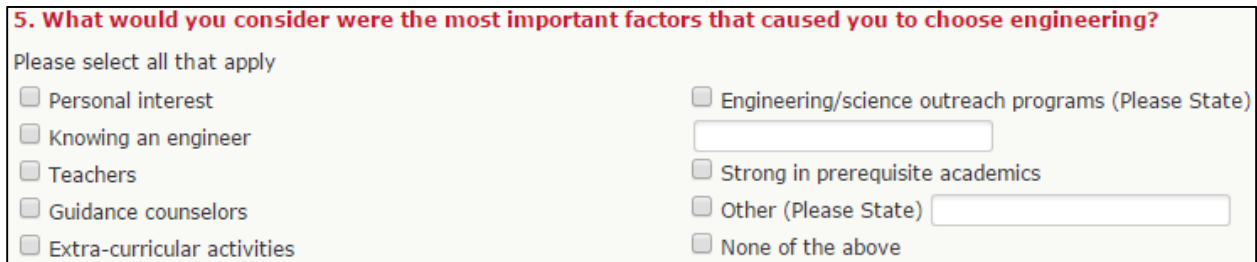
3.5 Measurement Instrument Design

3.5.1 Survey Design (Part A)

Surveys were selected as the measurement instrument for Part A, due to the large intended sample size. To reduce data entry, and potential resulting errors, the survey was conducted through FluidSurvey, an online survey tool licensed by Queen’s University. The survey was designed with three purposes in mind: to capture the demographics of the participant, to address the research questions, and to recruit participants for Part B.

A primary constraint of the survey was that it had to be brief. The intended method for conducting the survey was to enter classrooms with permission from instructors, and to gain this permission in as many cases as possible, the required time commitment was reduced as much as possible.

A copy of the survey can be found in Appendix C. To establish participant demographics, students were asked to report on their gender, degree year, international/domestic status and discipline. The next section was designed to examine reasons why students may have chosen engineering. The layout of Question 5 can be seen below in Figure 5.



5. What would you consider were the most important factors that caused you to choose engineering?

Please select all that apply

<input type="checkbox"/> Personal interest	<input type="checkbox"/> Engineering/science outreach programs (Please State) <input type="text"/>
<input type="checkbox"/> Knowing an engineer	<input type="checkbox"/> Strong in prerequisite academics
<input type="checkbox"/> Teachers	<input type="checkbox"/> Other (Please State) <input type="text"/>
<input type="checkbox"/> Guidance counselors	<input type="checkbox"/> None of the above
<input type="checkbox"/> Extra-curricular activities	

Figure 5: Visual layout of Question 5 from the survey in Part A

‘Personal Interest’, ‘Knowing an Engineer’, ‘Teachers’ and ‘Strong in Prerequisite Academics’ were suggested to be factors in the selection of engineering by Matusovich and Streveler (2010), as discussed in Section 2.1 [13]. ‘Guidance Counsellors’ was added as an option to draw comparison with ‘Teachers’. ‘Engineering/Science Outreach Programs’ are run by Queen’s and other universities, so it was included as

an option, and ‘Extra-Curricular Activities’ provided comparison. An ‘Other’ option was made available as a contingency to catch any factors that were not included.

Question 6 asked if participants knew an engineer prior to applying to university, offering: ‘Mother’, ‘Father’, ‘Sibling’, ‘Grandparent’, ‘Other relative’, ‘Friend’, ‘Other’ and ‘None’, and allowed multiple selections, similarly to Question 5. Question 7 asked students to indicate their level of satisfaction with their choice of engineering on a 4-point Likert scale. An even-point Likert scale was chosen to force students to specifically identify a presence of satisfaction or dissatisfaction, and a 4-point scale was chosen because the granularity of this question was limited. Questions 8a-8d were used to gather participants’ self-reported levels of understanding of the engineering program and profession currently and before application to university.

8. Please indicate your level of knowledge in the following circumstances.

	No Knowledge	Some Knowledge	Strong Knowledge	Complete Knowledge
a) How much knowledge did you have about the engineering program, prior to entering university?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
b) How much knowledge do you have about the engineering program currently?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
c) How much knowledge did you have about the engineering profession, prior to entering university?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
d) How much knowledge do you have about the engineering profession currently?	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 6: Questions 8a-8d, which asked student to report on their knowledge of engineering programs and profession currently and before application to engineering

Due to the repetitive nature of these questions, the questions were phrased distinctly, and coloured to highlight the important differences, as seen in Figure 6. Question 9 asked: ‘How likely are you to pursue a career in engineering?’, again using a 4-point Likert scale, this time from ‘Very Unlikely’ to ‘Very Likely’.

The third section of the survey asked students about their academic transfer, if applicable. Question 10a asked students if they had completed any academic transfers during their undergraduate degree, and can

be seen below in Figure 7.

10a. Have you completed any academic transfers (inter-discipline, inter-faculty, and inter-university transfers) during your undergraduate degree?

Please select all that apply

- No, I have stayed in the same program throughout university (Will hide question 10b)
- Yes, I have transferred between engineering *disciplines* (e.g. Mechanical to Civil) during my university career
- Yes, I have transferred between *faculties* (e.g. Arts and Science to Engineering) during my university career
- Yes, I have transferred between *universities* (e.g. University of Toronto to Queen's University) during my university career

Figure 7: Question 10a from survey in Part A

Question 10a acted as a ‘gatekeeper’ for question 10b, which the survey hid if the participant selected ‘No...’, because Question 10b was only pertinent for those who had transferred. Question 10b allowed students to describe their reasons for transferring through checkboxes labelled: Personal interest, Knowledge gained about the engineering program, Knowledge gained about the engineering profession, Career options, and Academic Difficulty. This question was only used to get an initial sense of reasons for transfer, and was subject to misinterpretation, as was revealed by interview analysis in Part B. This will be further discussed in Section 8.4.

Question 11 asked: ‘What is the role of math and science in the engineering profession?’, providing radio-button options of: ‘The focus’, ‘A useful tool’, ‘The heart and soul’, and ‘A necessary evil’. The effectiveness of Question 11 as an instrument to gauge participants’ understanding of engineering is unproven.

The final page of the survey asked students if they would be interested in being interviewed during Part B of the study, and if they were, to enter their contact email. A note added: ‘Students who have transferred during their undergrad are especially sought, but all participation is appreciated.’ to indicate to transfer students that their participation in Part B interviews was especially valued.

3.5.2 Interview Design (Part B)

The purpose of the interviews was to gain a deeper understanding of the phenomena involved, especially why students transfer into engineering from other programs. A semi-structured interview format was selected to ensure that all relevant questions were answered and simultaneously allow for further probing

into issues that were important to individual participants. The questions asked of participants and the corresponding purposes of those questions are provided below in Table 2. These questions were designed to mimic the survey questions from Part A, while ensuring to delve deeper to understand the personal thoughts and reasoning behind each answer.

Table 2: Questions and purposes for Part B interview

Question	Purpose of Question
1. What was your program choice upon entry to university, and what caused you to make that choice?	To get background information on the participant, and their initial program choices.
2. (a) Were you satisfied with that choice?	Timeline kept ambiguous in (a), to let the participant define the important moments in their reversal of choice.
(b) How has your satisfaction with that choice changed over time?	How long did it take to know that the participant wanted to transfer?
3. (a) When did you transfer into engineering?	To gain information on the actual transfer process and to examine the real-life cost of transferring between faculties during undergrad.
(b) How did the process work?	
(c) What was the cost to you in time and effort?	
4. (a) What were the reasons that you transferred into engineering?	What caused the participant's change of mind?
(b) Has [the new program] been a better fit?	Was is dislike/incompatibility with their initial choice, or attraction to their transfer-option?
5. Faculty transfer often represents a significant change in thinking. In what ways would you say that your perspectives on engineering as a program and as a profession have changed your initial program decision?	To place emphasis on the participants' changing perceptions of engineering as a program and profession.
6. (a) If you were able to go back to the time of your original entry decision, would you alter your choice?	To get a sense of how the participant feels about their transfer.
(b) If so, what information would have helped you make that preferred decision?	To take a guided look at what could potentially change the decision-making process of future students in the same situation.
7. Will your unusual path through university affect your career path after university?	To look at the long-term ramifications of their transfer, and how that will impact their future decision-making.

3.6 Data Collection

3.6.1 Survey Data Collection (Part A)

The survey was created and hosted on the FluidSurveys web client. Survey completion was tested on a laptop, a tablet and a smartphone to ensure functionality across devices. Instructors were then contacted via email and were asked for time to present during their class. The survey was estimated to take 5-10 minutes. Lecture periods from each of the 10 disciplines were selected for entry, in order to spread out participant demographic as much as possible. Upon entering lecture halls, the researcher did a short verbal introduction of the study and instructed students to enter a short URL link into an accessible web-enabled device, which directed them to the survey. This link was either written on the board or projected via PowerPoint for visual confirmation. Relying on students to have web-enabled devices on-hand was inherently risky, but proved to be a reasonable approach, as it resulted in approximately 70% participation by those who were present (done by head-counts). This may have been aided by the fact that students were assured that the survey worked well on a smartphone.

Overall, 416 surveys were collected, covering each of the years surveyed: 50% 2nd year, 24% 3rd year, 25% in 4th year or later, 1% “Other”. 59% of participants indicated that they were male, 40% indicated female, and 1% declined to identify their gender. All 10 disciplines were represented by participants, which is broken down below in Figure 8. This represents general oversampling of the smaller disciplines (Computer, Eng. Physics, Math. and Eng., Geological and Mining), and undersampling of the larger disciplines (Chemical, Mech. and Materials, Civil and Electrical). Electrical and Civil Engineering are especially undersampled, and this could decrease the accuracy of results.

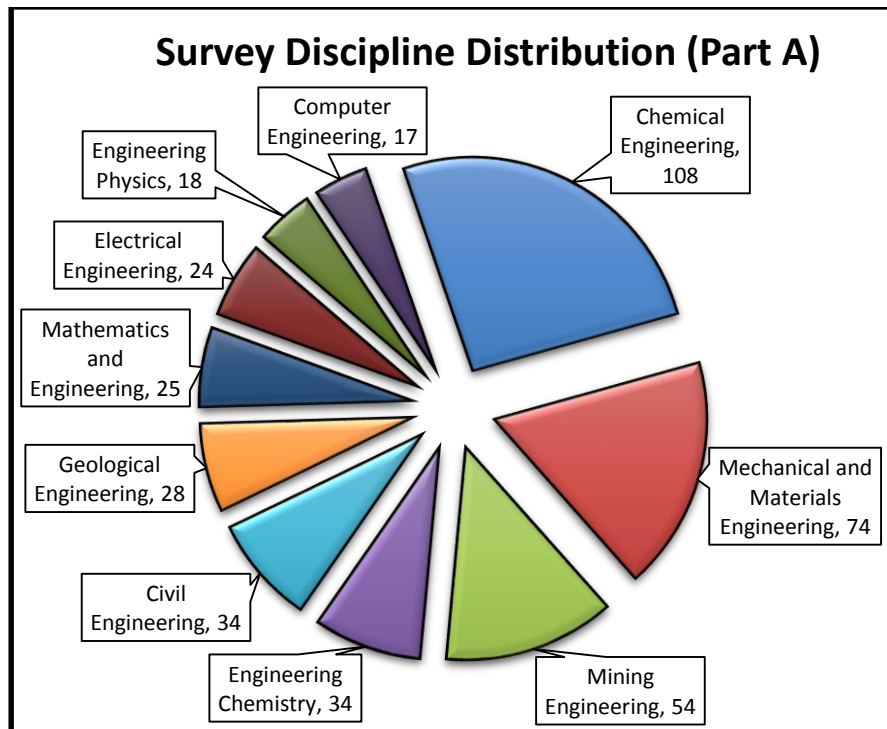


Figure 8: Survey submissions breakdown by discipline (Part A)

Forty-nine percent of participants completed their survey on a mobile device or tablet, while the remaining 51% used computers—ostensibly laptops, as surveys were completed in lecture halls without desktop computers. This suggests that to maximize the sample size of any future online survey, it should be easily accessible through both traditional computers and mobile devices.

Forty-eight students indicated an academic transfer: 20 indicated discipline transfer, 21 indicated faculty transfer, and 7 indicated institutional transfer.

3.6.2 Interview Data Collection (Part B)

Eleven participants were selected from the pool of those who indicated interest and provided contact information in Part A, and were contacted with an introductory email, to which seven participants responded. A chart profiling these participants can be found at the start of Chapter 5. Hour-long appointments were set up at times that were mutually convenient in group rooms in Beamish-Munro Hall, a building with which Queen’s engineering students are familiar. This familiar setting was chosen to help

participants feel as comfortable as possible during the interview process. Upon arrival at the group room, students were greeted and re-introduced to the purpose of the study. A Letter of Intent/Consent Form was signed, and students were verbally asked for permission to audio-record the interview. The participant was reminded that permission was/is voluntary, that they may withdraw from the study at any time, and that their data would only be referenced by a unique pseudonym. Participants were asked the questions mentioned above in Section 3.5.2, with unstructured discussion and clarification after each, to ensure complete understanding by both parties. Afterward, participants were asked if they had any further comments on their interview or the process, and thanked for their involvement.

Chapter 4

Quantitative Results and Analysis (Part A)

Results from each survey question were examined individually for trends, after which the results were tested against data from other questions to investigate expected trends. The quantitative analysis was primarily done with descriptive statistics, using chi-square testing to provide statistical significance. A discussion of further modelling/analytical techniques that were considered and/or attempted can be found in Section 4.3.1.

4.1 Statistical Tests Used

Two statistical tests were used to determine the significance of a difference in means or distribution. The majority of the tests were performed through chi-square analysis, while the questions which used a Likert scale were tested through Wilcoxon-Mann-Whitney testing.

4.1.1 Chi-Square Testing

Chi-square testing was selected as a versatile tool, on recommendation from a professor and expert in the field of quantitative education research [28]. Chi-square tests were used to evaluate differences between groupings, especially to determine whether a visual difference is statistically significant.

Four assumptions are required when performing chi-square tests: unbiased sampling, independent observations, mutual exclusivity of variables, and large expected frequencies [29]. Sampling was unbiased, and although purposeful sampling took place, it was to ensure that sampling was as evenly spread as possible across the engineering faculty. Observations were independent, given that participants completed the survey in class and had no incentive to collaborate. Not all variables captured were mutually exclusive, but exclusivity was ensured between the variables compared in any given test. Tests were also only be applied when sufficient frequencies were expected.

In this paper, p-values from chi-square testing are shown in parentheses after statements, which are calculated through the chi-square test, indicating the level of significance. This measure represents the likelihood that the measured result happened purely by chance, and thus reflects the α -error, or chance of a false positive. Results where $\alpha < 0.05$ were considered to be statistically significant. Statistics in parenthesis were found with a chi-square test unless otherwise indicated.

4.1.2 Wilcoxon-Mann-Whitney (WMW) Testing

Wilcoxon-Mann-Whitney (WMW) testing was applied when the data was ordinal, as is the case with Likert scale testing. Data is ordinal when responses fall into categories that have a defined order, but are not necessarily governed by a linear relationship. WMW testing is recommended by de Winter (2010) as the preferred statistical method for Likert-scale testing [30].

WMW testing was used in this section where indicated, and provided p-values, similar in nature to those calculated through chi-square testing. As before, results where $\alpha < 0.05$ were considered to be statistically significant.

4.2 Primary Statistical Analysis

The first portion of the survey was used to establish participant demographics, determining gender, academic year, international status, and engineering discipline. A brief analysis of these factors was discussed in Section 3.6.1, where it was shown that a wide cross-section of students from each gender, year, and discipline participated in this survey. This section will continue the survey analysis from Question 5.

4.2.1 Question 5: Causal Factors for Engineering Selection

Participants were asked to indicate which factors were important to their selection of engineering by selecting all applicable checkboxes, as seen in Figure 5, in Section 3.5.1. The options available can also be seen below, broken down by gender in Figure 9. Gender breakdown was used in many visual

comparisons because it is a point of interest in many studies, given the common occurrence of gender disparity in engineering programs.

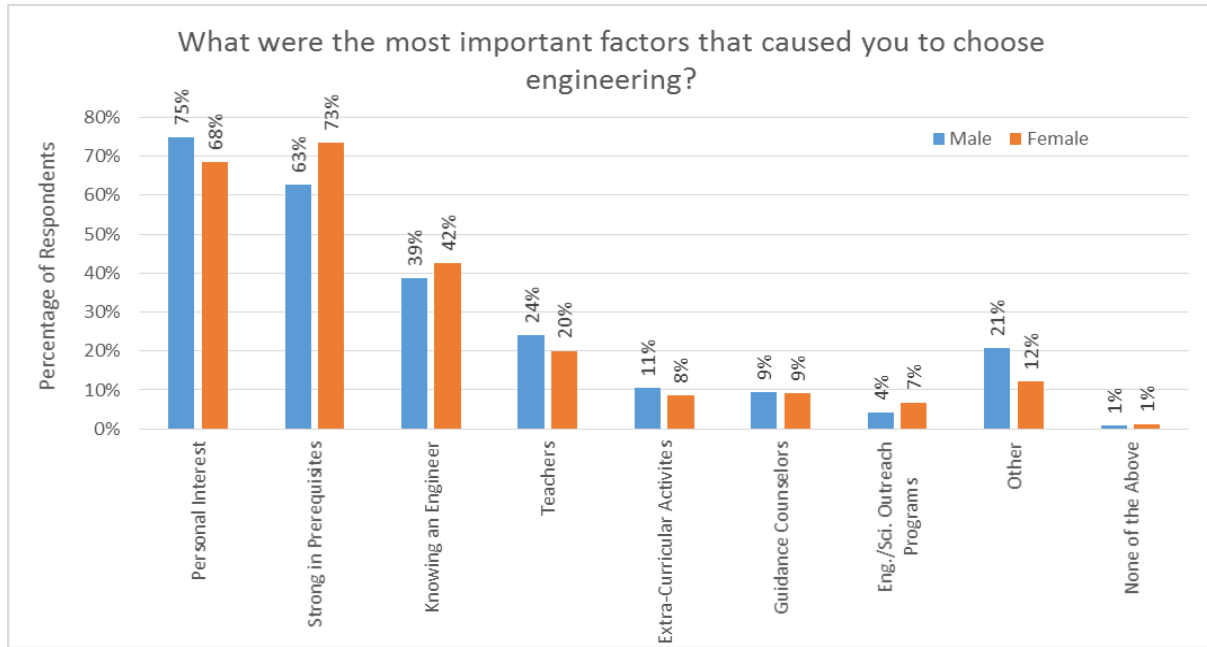


Figure 9: Question 5 selections, by gender

Those who selected the ‘Other’ option were prompted to enter their answer in text, and these answers were briefly analyzed. The main grouping of ‘Other’ responses indicated that vocational considerations were an important factor in their selection of engineering. Typical responses included suggestions that engineering careers have high earning potential, that jobs are available in the field, and that no further degrees are necessary. A similar factor was described in Part B, as is discussed in Section 5.3. Responses on Vocational Factors’ were tabulated, and in total, they were indicated by 34 participants or 8.2% of the total. Likely, this is an underrepresentation of students who consider this to be an important factor, due to the greater effort involved in entering the factor separately as opposed to simply selecting an available checkbox. This aspect will be further discussed in Section 6.1.1.5.

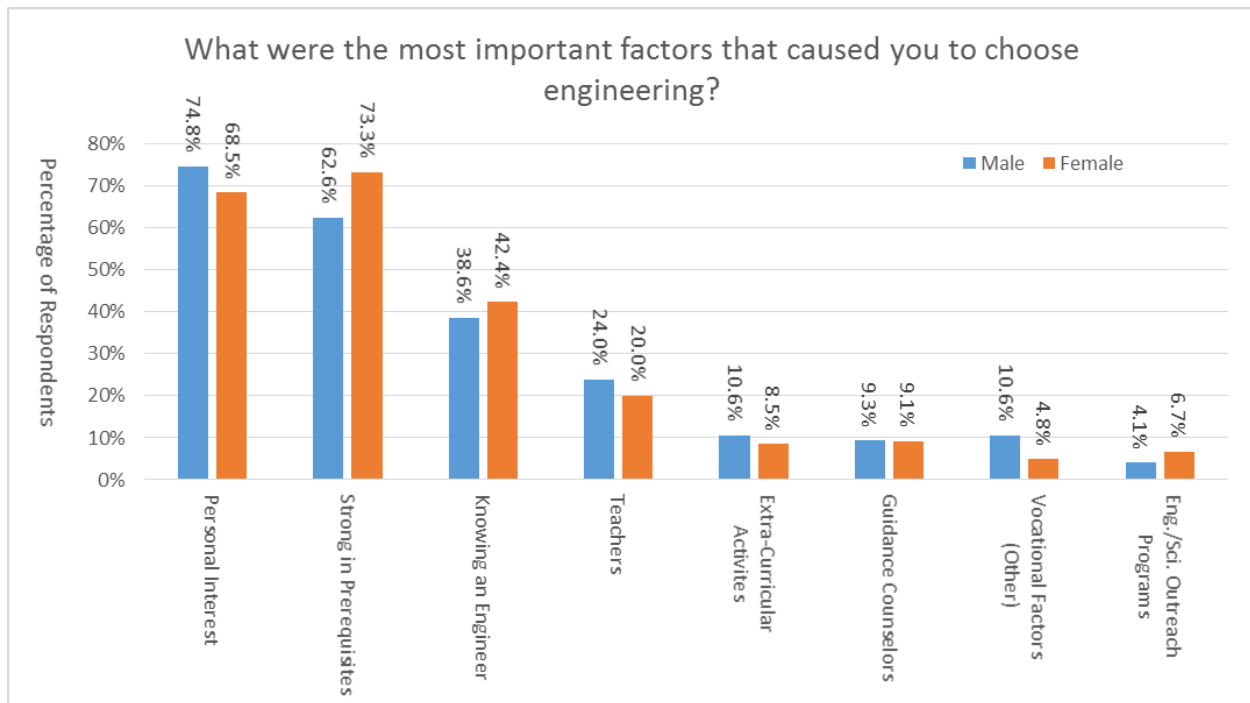


Figure 10: Question 5 selections, including vocational factors indicated in 'Other', by gender

Two gender differences on this graph are visually notable: in ‘Strong in Prerequisites’ and ‘Vocational Factors’. Chi-square tests were applied, and both were shown to be statistically significant differences.

More females consider ‘Strength in Prerequisites’ as a factor than males

($p=0.024$), and more males consider ‘Vocational Factors’ important than females ($p=0.039$). Otherwise, responses were seen to be consistent between genders. ‘Personal Interest’ was statistically tested for gender differences, but no differences were found ($p=0.161$).

Teachers and guidance counsellors play a similar role in a student’s career path, however their impact is visually different. 22.4% of participants selected ‘Teachers’ as a factor, while only 9.1% of students selected ‘Guidance Counsellors’, which was found to be a statistically significant difference ($p=0.025$).

4.2.2 Question 6: Personally Knowing an Engineer

Participants were asked if they personally knew an engineer prior to their initial application to university. Checkboxes were supplied for ‘Mother’, ‘Father’, ‘Sibling’, ‘Grandparent’, ‘Other Relative’, ‘Friend’ and ‘Other’. A bar graph of participant selections can be seen below in Figure 11.

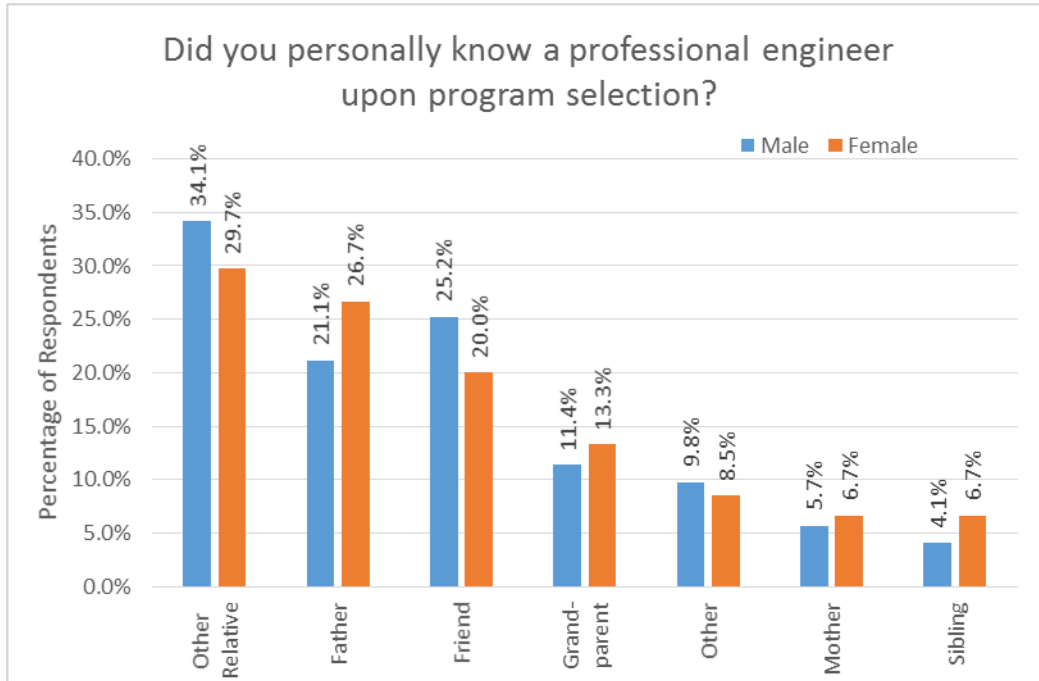


Figure 11: Question 6 selections, personal knowledge of professional engineers, by gender

In order to determine how *many* students knew a professional engineer before their program selection, a histogram was generated and can be found below in Figure 12.

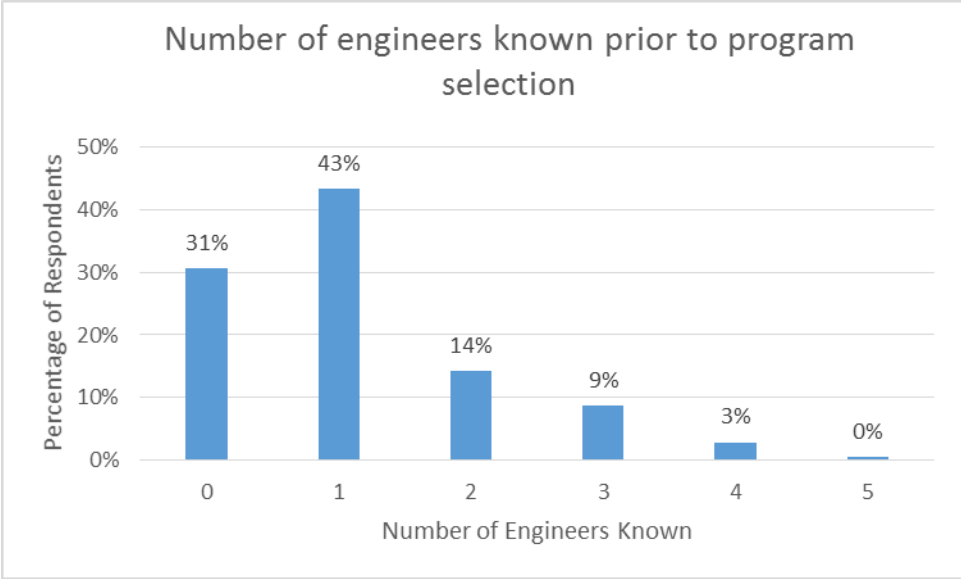


Figure 12: A histogram indicating the number of engineers know by participants prior to initial program application

This most distinctive feature of this histogram is that shows that only 30.5% of students entered university without personally knowing an engineering beforehand. Reciprocally roughly 70% of students indicated knowing at least one engineer prior to entry. These students with personal knowledge of ‘Any’ engineer were added to the results graph for visual comparison in Figure 13.

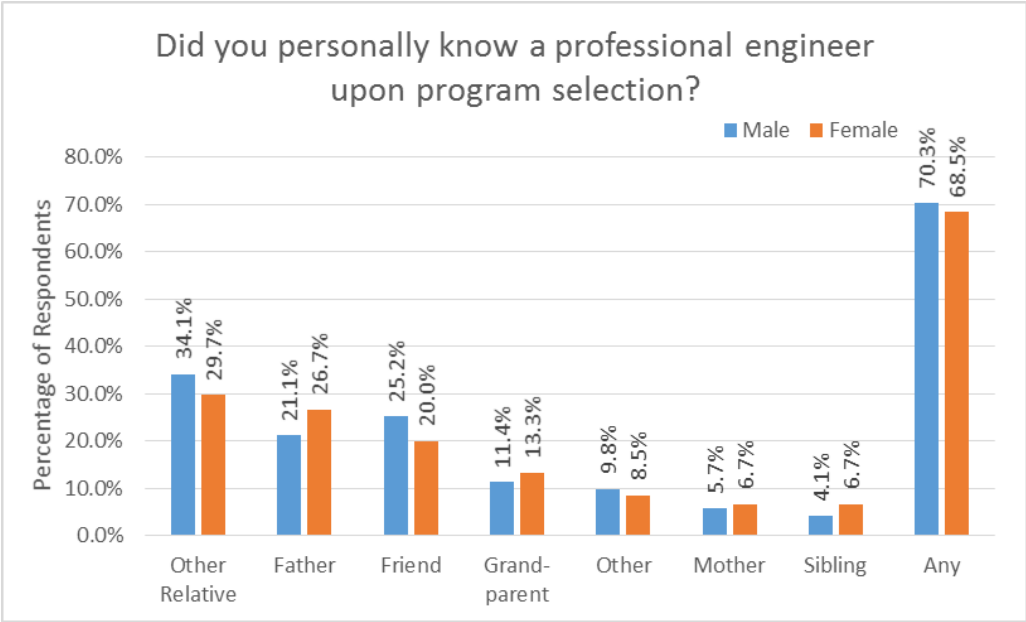


Figure 13: Question 6 responses, with 'All' column included, by gender

Male and female columns track closely, with the most apparent visual divergence presenting on ‘Father’. A chi-square test was applied, and this difference was found to be insignificant ($p=0.194$).

4.2.3 Question 7: Level of Satisfaction

Participants were asked to self-report their level of satisfaction with their selection of engineering on a Likert scale, given options of ‘Very Unsatisfied’, ‘Unsatisfied’, ‘Satisfied’ and ‘Very Satisfied’. Specifically, participants were asked: “Looking back, how satisfied are you with your decision to enter engineering?”

About 90% of participants indicated that they were either ‘Satisfied’ or ‘Very Satisfied’ with their decision, as seen below in Figure 14.

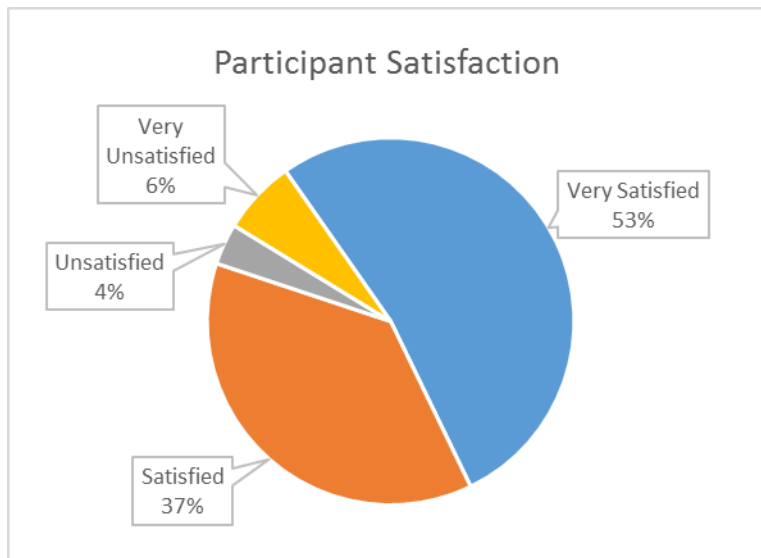


Figure 14: Question 7 responses, self-reported satisfaction

Participants were separated by gender and degree year to explore the data for trends, as seen below in Figure 15 and Figure 16.

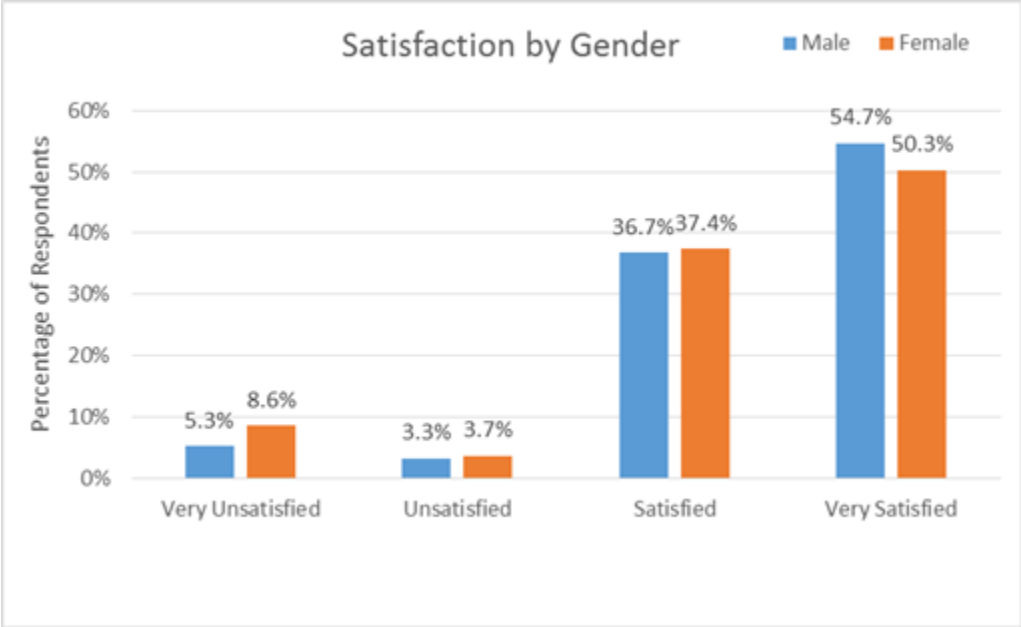


Figure 15: Satisfaction, by gender

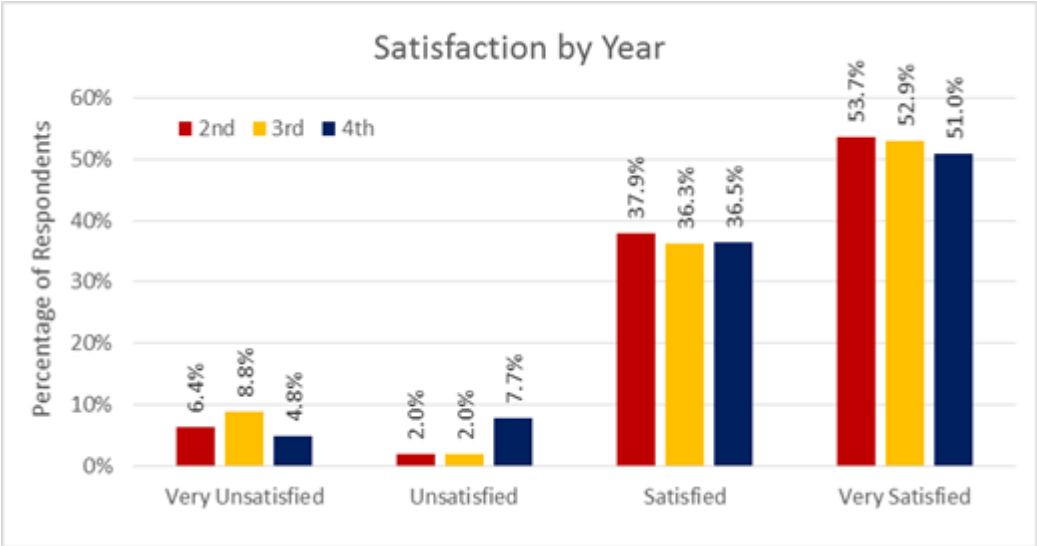


Figure 16: Satisfaction, by year

Figure 15 and Figure 16 show consistency across gender and year, which was corroborated by applied WMW tests by gender ($p=0.428$) and year ($p=0.501$), each denoting statistical insignificance.

4.2.4 Question 8: Participant Knowledge of Engineering Programs and Careers

Students were asked about their current knowledge of engineering programs and careers, as well as the knowledge they had prior to program application. Question 8 was broken down into four parts as demonstrated below in Table 3.

Table 3: Visual layout of Question 8, parts a)-d)

	Prior to Entry	Currently
Engineering Program	a)	b)
Engineering Profession	c)	d)

For example, 8.a) was phrased: “How much knowledge did you have about the engineering program, prior to entering university?” Results for Question 8 are summarized on the chart below in Figure 17.

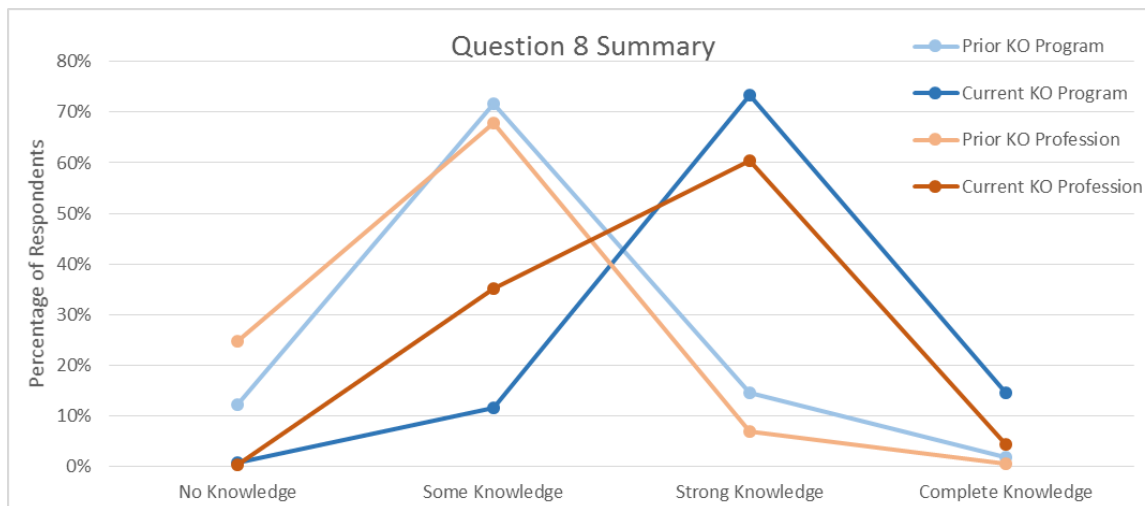


Figure 17: Summary of Question 8. “KO” in legend stands for “Knowledge of”.

Unsurprisingly, reported participant knowledge of the engineering program and profession rose significantly since program entry, as was confirmed through statistical testing (both $p < 0.0001$). It was suspected that students who knew a professional engineer prior to program application were more likely to know about the engineering profession, and this was graphed below in Figure 18.

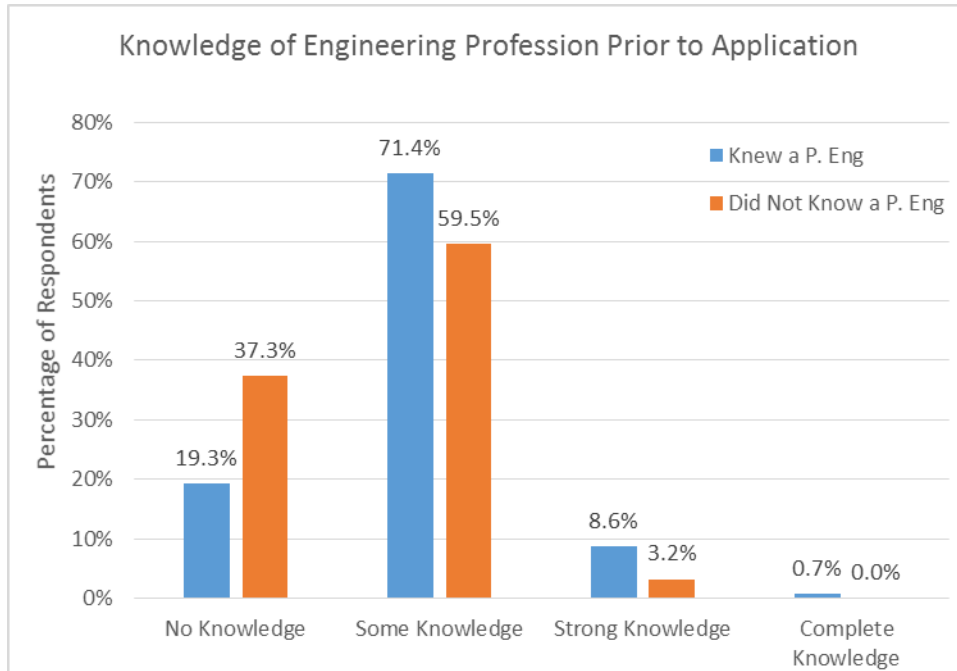


Figure 18: Knowledge of engineering profession prior to university application, by whether or not the participant knew an engineer prior to application

It is visually apparent that students who knew a professional engineer were more likely to have knowledge of the engineering program before application. This was found to be a statistically significant effect ($p < 0.0001$) by WMW.

In contrast, this graph was repeated for knowledge about engineering *programs* prior entry, and the visual difference is diminished, as can be seen below in Figure 19. A WMW test was applied to this, and the relationship was found to be insignificant ($p = 0.158$).

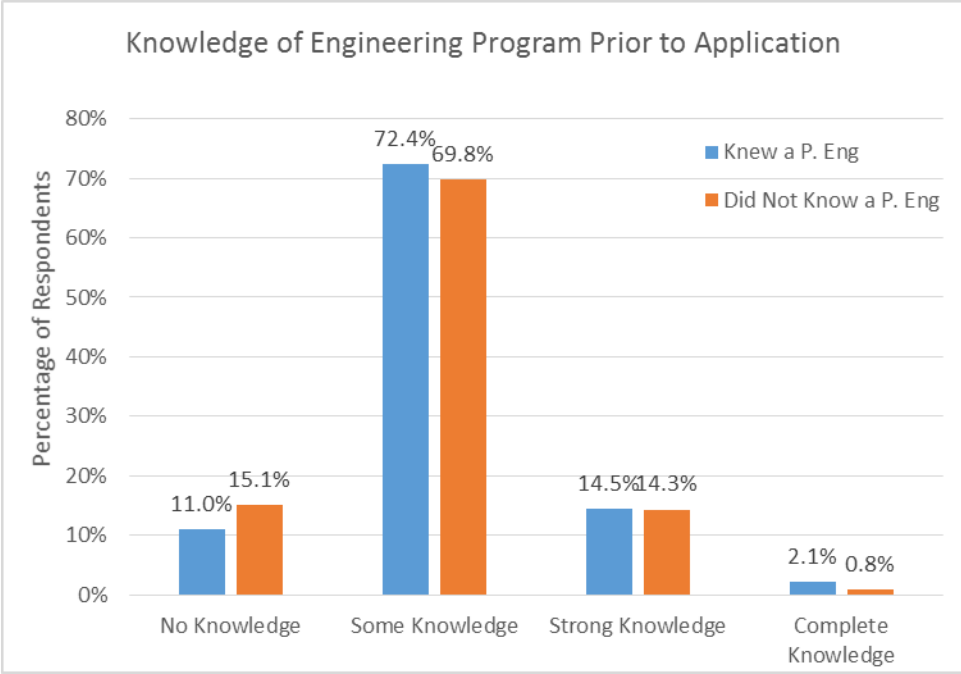


Figure 19: Knowledge of engineering *program* prior to university application, by whether or not the participant knew an engineer prior to application

4.2.5 Question 9: Likelihood of Pursuing an Engineering Career

Most participants considered themselves either likely (43%) or very likely (41%) to pursue an engineering career. Participant selections are displayed below in Figure 20, separated by gender.

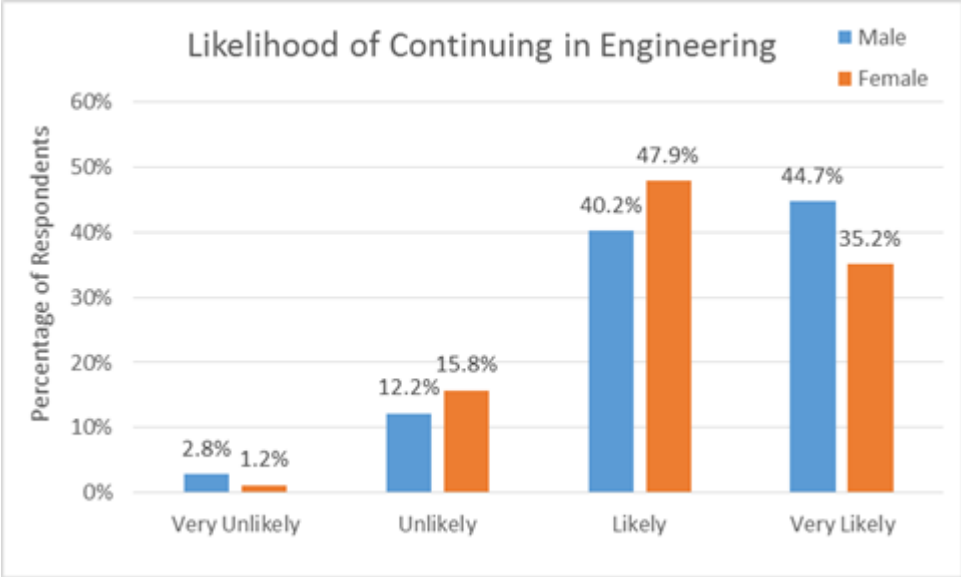


Figure 20: Self-reported likelihood of continuing on to an engineering profession, by gender

There appears to be a trend, based on the larger proportion of males who indicated that their continuance to an engineering career was ‘Very Likely’, the difference was found to be statistically significant by WMW ($p=0.049$).

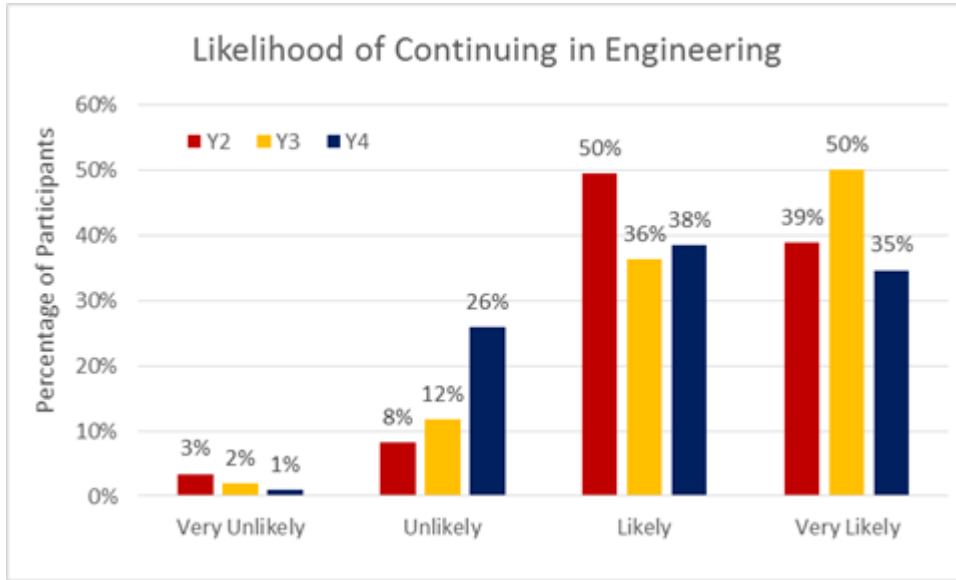


Figure 21: Self-reported likelihood of continuing on to an engineering profession, by year

It can be seen that the perceived likelihood of pursuing an engineering career decreases in fourth year.

Statistical testing detected this relationship between year and perceived likelihood of continuing on to an engineering career through WMW ($p=0.0225$).

The model proposed in Section 0 suggested a connection between satisfaction with program and academic retention. Although Question 9 asked whether participants expected to continue on to an engineering profession, as opposed to whether they would finish their degree, it helps provide an empirical connection between these concepts. To visualize the relationship between these two variables, a heat map was created, as shown below in Figure 22.

Satisfaction with program selection	Very Satisfied	4	11	86	116
	Satisfied	3	31	81	39
	Unsatisfied	1	9	3	2
	Very Unsatisfied	2	3	10	12
		Very Unlikely	Unlikely	Likely	Very Likely
		Likelihood of Continuing to an Engineering Career			

Figure 22: Heat map of satisfaction with program vs. likelihood of continuing to an engineering career

General clustering of values along the bottom-left to top-right diagonal indicate a correlation, although this is obscured by the obvious skew toward the top-right corner (Very Satisfied/Very Likely). This supports a link between satisfaction with program selection, and inclination to enter the engineering workplace. This link was further supported by a chi-square correlation ($p=0.0001$).

4.2.6 Question 10a: Academic Transfers of Participants

Participants were queried as to whether or not they had undergone an academic transfer, and if so, what type of transfer it was. This question was primarily to help select participants for the interviews in Part B. Forty-eight students indicated that they had made an academic transfer, as broken down below in Figure 23.

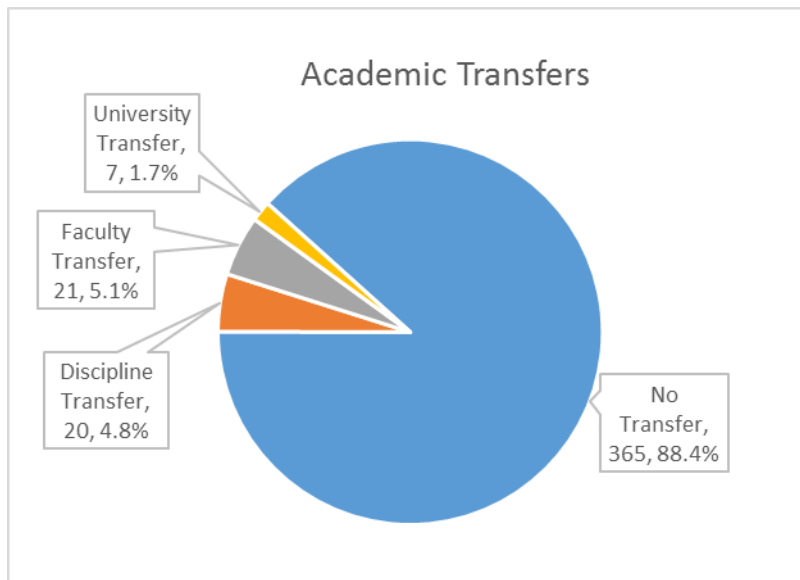


Figure 23: Academic transfers undergone by participants

The proportion of transfer students was slightly more than one would expect from the statistics discussed in Section 1.4.1, but not unreasonable considering that these transfer students were especially encouraged to take part in the study.

4.2.7 Question 10b: Factors for Transfer

Question 10b was only available to participants who indicated an academic transfer. These participants were asked to indicate ‘the most important factors that led to [their] transfer’ through checkbox selection. Participants were also offered an ‘Other’ checkbox, so that they could fill in their own answer, and although it was checked by 1 ‘Faculty Transfer’ and 4 ‘University Transfer’, no cohesive text responses were provided. A breakdown of the responses can be found below in Figure 24.

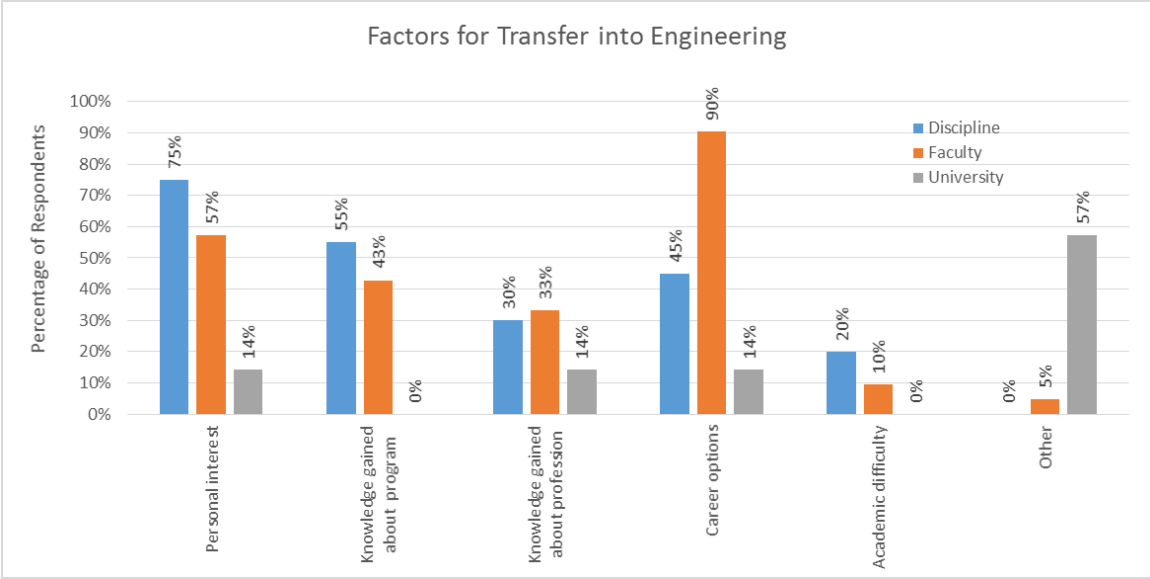


Figure 24: Factors for transfer into engineering, by academic transfer type. Please note small samples sizes of (Discipline: 20, Faculty: 21, University: 7)

It is apparent that the supplied ‘checkbox’ factors were not useful for ‘University Transfer’ participants, although this was expected, as the question was intended to be answered by discipline and especially faculty-transfer students.

Fifteen of the 20 participants who transferred between disciplines indicated that personal interest was an important factor. These students also indicated knowledge gained about the engineering program and profession, as well as difference in career options available.

Faculty transfer students were the focus of Part B, so their selections were isolated below in Figure 25, sorted by their prevalence.

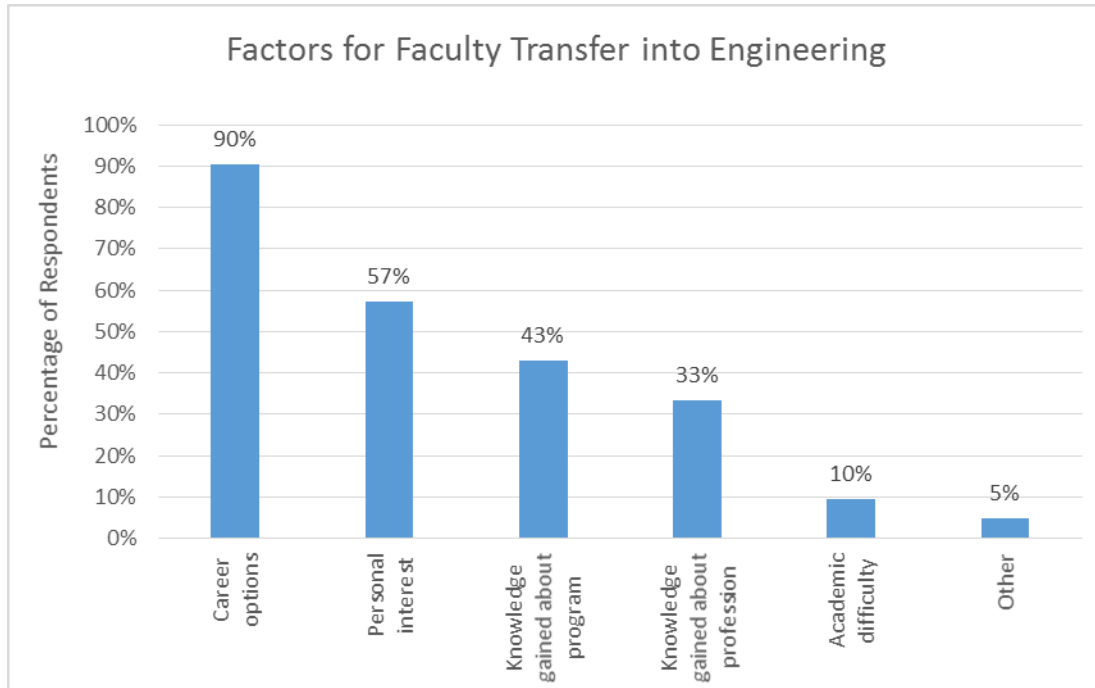


Figure 25: Factors for Faculty Transfer into Engineering (n=21)

The most commonly identified factor was the career options provided by engineering, as it was reported by 90% of respondents. These factors and others were addressed in the Part B interviews, a complete analysis of which can be found in Chapter 5.

4.2.8 Question 11: Indirect Evaluation of Participant Understanding of Engineering

Question 11 was designed to measure the ‘actual’ understanding of engineering, as discussed in Section 3.5.1. The majority of students (67%) ‘correctly’ identified the ‘role of math and science in engineering’ as ‘A useful tool’, as seen below in Figure 26.

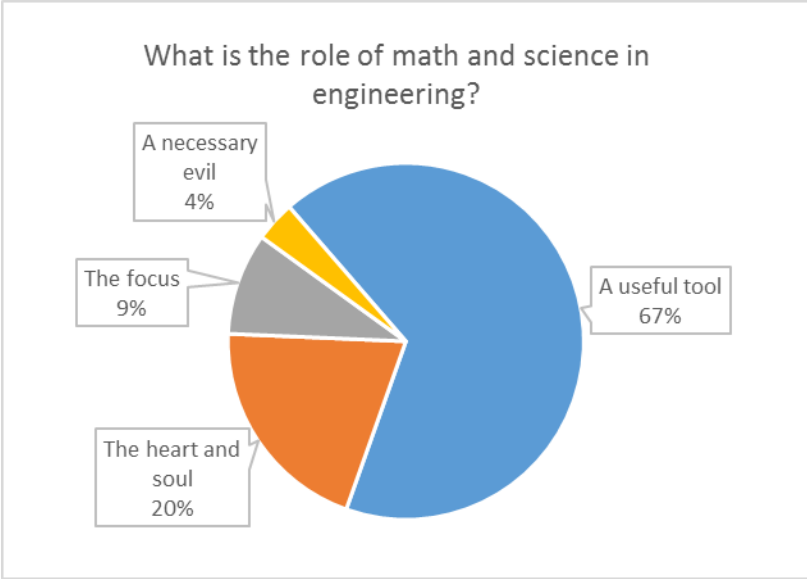


Figure 26: Results from Question 11

Assuming this question properly evaluates a student’s understanding of engineering, it would logically follow that a greater proportion of participants would ‘correctly’ answer the question in later years. This was not seen to be the case, as shown below in Figure 27.

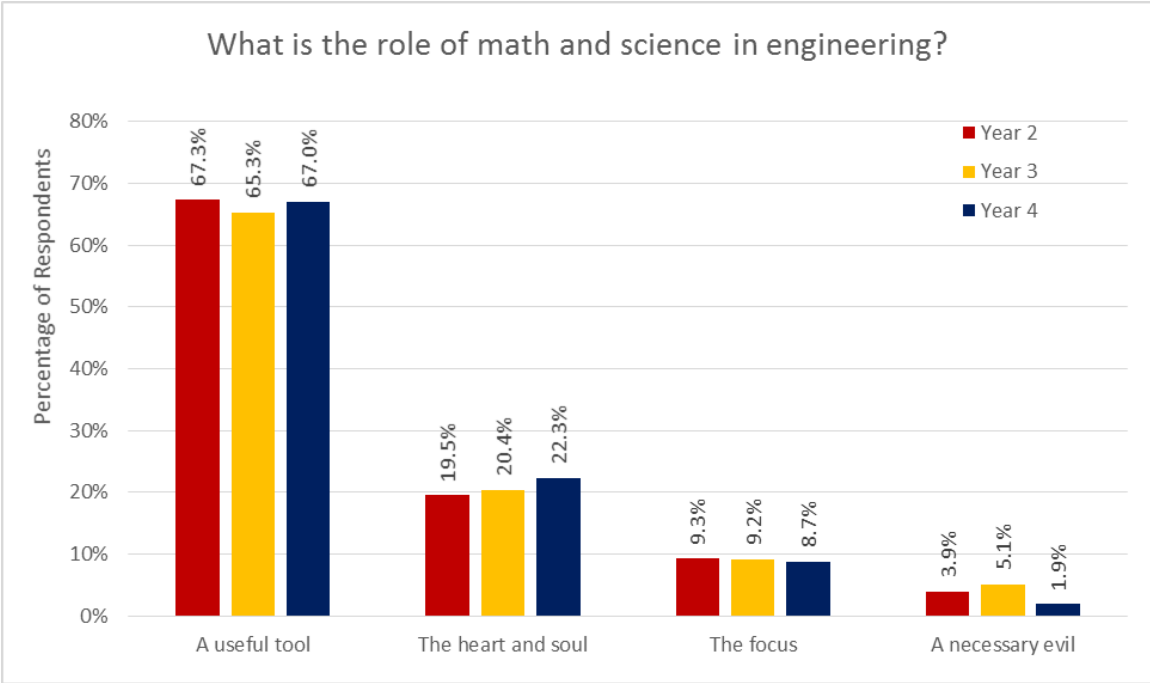


Figure 27: Question 11 "What is the role of math and science in engineering", by year

There is very little visual difference shown between years, and this was verified statistically ($p=0.476$). A crosstab analysis was run to compare answers to Question 11 across disciplines.

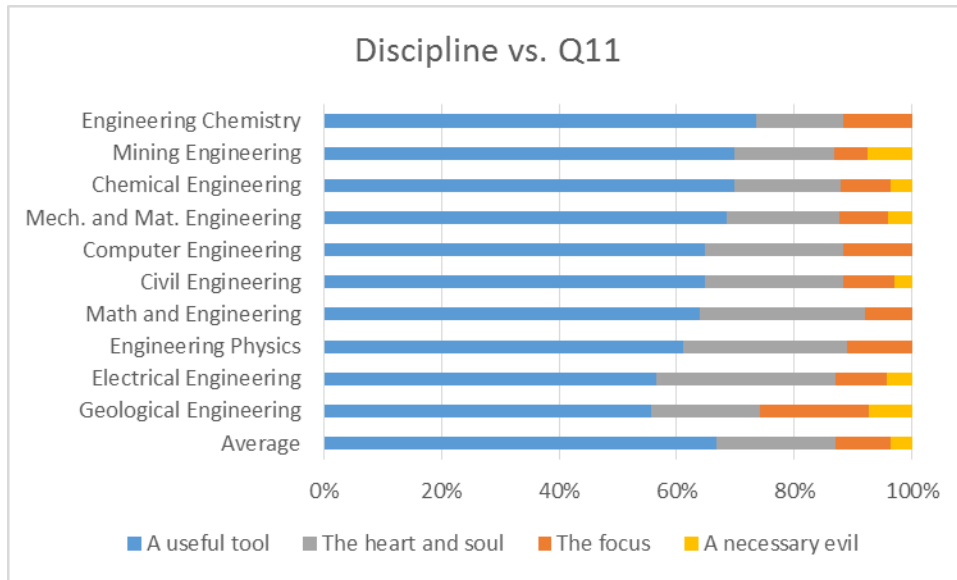


Figure 28: Question 11 selections, by discipline

Little variance was shown between disciplines, and a chi-square test found differences to be insignificant ($p=0.98$). Although two of the more theoretical disciplines, Geological Engineering and Engineering Physics have a lower proportion of participants who selection ‘A useful tool’, another highly theoretical discipline, Engineering Chemistry has the highest proportion. This indicates no apparent trend between discipline and answer to Question 11.

4.3 Correlation with Satisfaction

Research Question #2 reads: What relationship do [program selection] factors have with program satisfaction? Question 7 asked participants to self-report their level of satisfaction with their program selection: “Looking back, how satisfied are you with your decision to enter engineering?”

To answer the research question, a method was found to compare participant answers on Question 7, with selections for other questions. The use of checkbox questions in the survey worked to severely limit the options available, because checkboxes offer significantly less variation than scale-based questions. This binary input prevented the use of common statistical modelling tools, as discussed below in Section 4.3.1.

A correlation table was identified as a particularly robust tool for comparison of variables, which was most likely to generate reliable results with binary variables [28]. To generate a correlation table, Pearson correlations were calculated for each pairing of variables, and these were placed into a table, as shown below in Table 4.

Table 4: Correlation table between satisfaction and other survey variables

Question	Selection/Variation	Correlation with Satisfaction
Q5: Factors for Entry to Engineering	Personal Interest	0.168
	Knowing an Engineer	0.004
	Teachers	0.051
	Guidance Counsellors	-0.092
	Extra-Curricular Activities	0.017
	Eng./Sci Outreach	0.007
	Strong in Prerequisites	-0.004
Q6: Personal Relationships with Engineers	Mother	0.008
	Father	-0.036
	Sibling	-0.073
	Grandparent	0.084
	Other Relative	0.015
	Friend	0.023
Q8: Knowledge of Engineering Program /Profession	a) Program/Prior	0.014
	b) Program/Currently	0.094
	c) Profession/Prior	-0.055
	d) Profession/Currently	-0.030
Q9: Likelihood of Continuing in Eng.		0.274

According to Cohen (1988), in behavioral studies, a Pearson correlation with an absolute value greater than 0.1 can be considered to have a correlation, following the scheme seen below in Table 5 [31].

Positive R-values indicate a positive correlation, while negative R-values indicate a negative correlation.

Table 5: Interpretation of correlation values from Cohen (1988) [31]

Coefficient Value	Strength of Association
$0.1 < r < .3$	Small correlation
$0.3 < r < .5$	Moderate correlation
$ r > .5$	Strong correlation

Based on this interpretation, two variables showed a correlation with the satisfaction variable, although both are considered ‘small’: Likelihood of continuing to an engineering profession ($r=0.274$), and personal interest as an important factor in selecting engineering ($r=0.168$).

4.3.1 Alternative Methods Considered

Two alternative methods were identified and considered for statistical modelling in order to identify factors which related to satisfaction with program selection: regression modelling and factor analysis. The checkbox nature of many questions was a primary constraint, in that this low level of granularity made modelling options unreliable [28].

Regression modelling was considered as an option, as it is able to isolate the effects of individual variables on a single resultant variable, but they are not commonly used in social sciences, where many factors are linked, and effect sizes are small. Logistic regression was especially considered, but along with the issues regression modelling has in general, it requires a binary outcome. For this reason, it was successfully used in Marra (2012), Levine & Wyckoff (1990), and Besterfield-Sacre (1997), which examined retention as a simple binary (stay or go) [20], [21], [32]. Separating students in to a binary of satisfied/very satisfied vs. unsatisfied/very unsatisfied, but this was both arbitrary, and left a relatively small unsatisfied/very unsatisfied group, which would significantly decrease the statistical power of the model.

Factor analysis was considered, because it is commonly used on Likert-scale data to determine which factors ‘overlap’. The survey conducted in this study did not logically fit this model, because questions were not designed to overlap, in that many of the questions were simply to gather objective data, such as whether or not the participants’ parents were engineers. Further, factor analysis was not considered to be robust enough when operating with binary variables, such as checkboxes [28].

Instead of these other two techniques, a correlation table was selected as a robust way of comparing the satisfaction variable with others.

Chapter 5

Part B: Qualitative Data and Analysis

The interview participants were selected from those who indicated interest in Part A, as discussed in Section 3.6.2. These participants will be referenced by their assigned alias throughout this chapter. Each alias was assigned to correspond to their indicated gender for clarity. Each participant was currently in engineering when the interviews took place. Five of the participants had completed a transfer between faculties, one completed a transfer between engineering disciplines, and one started and remained in engineering. Five indicated their gender to be male, while two indicated their gender to be female. The participants are listed below in Table 6 for reference.

Table 6: Interview participants by alias

Alias	Year	Gender	Discipline	Transfer Type
Andrea	2nd	Female	Geological Engineering	N/A
Cameron	4th	Male	Mechanical Engineering	Faculty
Jeremy	4th	Male	Engineering Chemistry	Faculty
Matthew	2nd	Male	Chemical Engineering	Faculty
Paul	4th	Male	Engineering Physics	Discipline
Sarah	4th	Female	Computer Engineering	Faculty
Thomas	3rd	Male	Mining Engineering	Faculty

Data from each of these participants can be found in this chapter. Their greater presence in some sections than others reflects the contents of their interview specifically, because although participants were prompted with the same questions, discussion followed distinctly varied trajectories.

The transcribed interview data was initially analyzed through the process of open coding. Rough categories were constituted from apparent trends in the data in accordance with Patton (2001):

“Developing some manageable classification or coding scheme is the first step of analysis.” [27]. NVIVO was used to sort extracts of data into these categories, and categories were constantly added and combined. This worked to continually update and direct the scope of categorization. Categories were organized so that each was mutually exclusive.

These categories were gathered into four themes, which were identified as: Early Career and Program Learning, Discovery of and Identification with Engineering Values, the Strength of an Engineering Degree, and Transfer Considerations and Impacts. Under each theme, subthemes were identified and in some cases, subthemes were further broken down and discussed.

5.1 Learning About Engineering Program and Profession Prior to Program Selection

Two sources were indicated by participants as influential to their program selection process, and their understanding of both engineering programs and the engineering profession: Secondary School and Professional Engineers.

5.1.1 Importance of Secondary School to Program Selection

When students select a post-secondary program, it is important that they know both what that program entails and which careers that program will likely lead to. This knowledge increases the likelihood of both academic and vocational fit. A half-credit course called Career Studies is mandatory in the Province of Ontario, with the stated goal of “*explor[ing] postsecondary learning and career options, [and] prepar[ing] students for managing work and life transitions*” [33].

Two participants commented on poor execution of Career Studies curricula. Andrea suggested that the primary activity in her careers class was writing cover letters, and that her class was particularly limited due to being incorporated into her French Immersion curriculum: “*[Career Studies] was dumbed down a little bit, so that we could actually cover material, and speak French at the same time.*” Andrea also indicated that the variety of careers discussed was limited: “You could be an engineer, you could be a doctor, you could be... a pharmacist, like all the different titles, [but] you didn’t really know much past that?” She further discussed her knowledge gained on engineering, indicating: “*I knew an engineer as math and science, but in high school, I didn’t really know anything past that.*” Sarah suggested that there was especially little focus on science or engineering careers.

Andrea and Sarah both suggested that internet quizzes were the prime memorable processes in Careers Studies. Andrea detailed her memory:

“After taking the 3000 questions, after going ‘continue, continue, continue’ on the career advice thing, I ended up with ‘I should be a sprinkler system installer’, as my number one choice. And I think number two was I think, a garbage man? [Andrea laughs] Which, I may be very happy doing, but it really didn’t help steer me because I knew that wasn’t where I was headed in life.”

The quiz appears to have failed to account for practical career aspirations. Similarly, Sarah suggested that the list of careers given to her was “*stupid*” in suggesting she should be a florist: “*and I’m obviously not going to be a florist!*”

Participants’ understanding of engineering careers was limited prior to program entry. Paul said that prior to university, he specifically lacked an understanding of: “*the whole picture of engineering—like I knew I like technology, and like that’s clearly like a very—it’s a smaller part of engineering, there’s kind of like this huge professional aspect to it.*” Sarah described her misconceptions of the engineering profession during high school: “*an engineer, like a train engineer? Like a train conductor?*”

Sarah and Cameron specifically mentioned physics as a linchpin on their path toward engineering. Sarah suggested that her main reason for declining to continue in high school physics was that it was “*uncool*”. Not only does this indicate a stigma toward physics, but Sarah’s case directly shows one way that a student can become ineligible to continue to engineering. Sarah only later became eligible upon completion of physics courses in university. Cameron was intending to enter an engineering program, until he had a bad experience in his Grade 12 physics class, which in his opinion, was due to his instructor: “*he was just a bad teacher and I had—I didn’t have a good experience in my physics class.*” This led him to select a different program: “*I was taking biology and chemistry and I loved those. [So I decided to] do life sciences [or] biochemistry.*”

5.1.2 Influence from Professional Engineers

The other stated source of information about engineering programs and the engineering profession, prior to university, is from engineers themselves. Growing up, Cameron spent a lot of time around his cousin and his cousin's friend, both mechanical engineers. He was exposed to a wide variety of 'tinkering' and hobby-related work, and apparently discussed engineering with them at length:

"I got to know what they did as engineers, and to me, I essentially drew that parallel of: they just—a client comes to them and has this problem, or asks them to build something, and they fix the problem, or build it."

This is a particularly apt description of engineering at this level, and further, he identified with this image:

"that's what I enjoy, [and] I instantly drew [a] connection that this is just awesome."

Jeremy had a significantly different experience with engineers he knew, including his father, saying: *"I've had a few family members do engineering and they weren't like super big fans of it, so maybe that kind of pushed me away from it."* However, he later suggested that his father was supportive of his transfer into engineering, suggesting: *"my dad is an engineer himself, so I don't think [it was] a big problem that I went back for a fifth year for him, I don't know, I feel like he preferred that I was in engineering – he was okay with that."*

When Andrea was applying to university, based on her stated interest in geology, her grandfather who is a professor of engineering at Western University, sent her information on Queen's geological engineering program. She further discussed her early impression that *"engineering was a good program... it was a hard program, and it was all sciences and stuff."*

Cameron had a relatively deep understanding of engineering as a profession, Jeremy had a vague but negative association, and Andrea was given a description of what engineering programs are like, as well as the knowledge of a specific discipline where she might fit. These three accounts demonstrate very different pools of information gathered, depending on the nature of the interaction. It can be noted, that of these three participants, only Andrea initially selected engineering (she was selected for the 'control' interview).

5.2 Discovery of and Identification with Engineering Values

The interview participants identified a wide variety of reasons that they transferred into engineering, but the most prominent reasons were unexpected and undocumented by other research. Every participant interviewed primarily discussed their reasons for transferring into engineering through their identification of engineering values. Students invariably gathered this information about engineering values from their university peers who were themselves in engineering. Both social/cultural and academic values were presented, and they will be discussed separately in this section. It is important to note that from the position of this research, it is unknown whether or not these perspectives are transferrable across institutions, especially due to the uncommon qualities of the Queen's Engineering program, as discussed in Section 1.3.

5.2.1 Peers as the Source of Value Discovery

Four participants indicated that the information that propelled them to transfer into engineering was derived from peers already in engineering. Peers are an obvious source for information on alternative programs, as they are accessible and mutual trust has been established. Cameron indicated: *"Half of my floor in residence was engineers, and they actually all ended up being my friends, so I learned a lot about first year engineering from that."*, which exemplifies this principle. Thomas' roommate in First Year was an engineering student, and he suggested that: *"seeing what he was up to, I thought it was kind of cool"*. This simple element of exposure to engineering was discussed by Sarah as well: *"I had a couple of friends on my floor who were in engineering, in their first year, and I saw some of the things that they were doing, and they appealed to me a lot more."* Cameron further discussed the ways in which he saw his peers in engineering working; *"everyone worked together to get things done."*

5.2.2 Social/Cultural Values

Three participants identified values embedded in the culture of Queen's Engineering that were not directly related to academics.

Thomas explained that the culture of Queen's Engineering was an important draw to the program: "*Part of the interest initially arose from [Queen's engineering jackets], and the whole tradition behind that—that's undoubtedly a big draw.*" He also explained that in his opinion, Queen's Engineering Orientation Week was "*far superior*" than the Faculty of Arts and Science Orientation.

Cameron and Jeremy spoke directly to their perception of engineering students prior to entering university, and how these perceptions changed. Cameron spoke specifically to his expectation of students in the engineering program:

"I was expecting engineering to be a lot less social [than other programs] ... and that's completely not the case. I find no difference who students are in engineering and arts and science. I was kind of expecting it, but everyone's the same—we're all just students."

Jeremy evaluated the image of Queen's Engineering students more broadly, suggesting that: "*in high school, engineering didn't seem like the coolest, most [hip] thing to get into*", but later determined that was the "*most cool and [hip] thing*". Jeremy was very animated in this discussion of the social status of engineering students, and it was obvious to the researcher that it held a large amount of personal importance. Jeremy further suggested using this knowledge as a strategy to recruit more students to engineering: "*show off... exactly what engineering is at Queen's – display that... engineering has a good reputation here at Queen's for being... fun.*"

These cultural factors are likely to differ dramatically between engineering schools, because unlike academics, school culture is organic with little cross-university exchange.

5.2.3 Academic Values

Academic values were mentioned as important factors for transfer into and fit in the engineering program, by six of the seven participants. Three distinct academic values were identified: co-operation/group work, practicality, and problem solving.

5.2.3.1 Co-Operation/Group Work

Thomas compared science and engineering programs:

“I had a sense in science that it was very competitive, that there was very little assistance provided to each other because it’s this... fear—this nagging fear that by helping this one person now, on this one project, could mean the difference down the road, of them eking you out of that one spot left in med school, or whatever, there’s very little collaboration, very little help—it’s so competitive and cut-throat.”

Thomas’ use of negative phrasing, such as ‘nagging fear’, ‘very little help’ and ‘cut-throat’ intimate his negative feelings toward his time in the science program, which he later identified as a reason to leave the program: *“This kind of academic competitiveness is not something that I think is a very healthy environment—it was nice to get out of there.”* Thomas then contrasted the science program with engineering, citing: *“In engineering, there’s this feeling that you’re all working together toward the same goal and that you just have to survive. So you surround yourself with people who can help you just make it through.”*

Similarly, Cameron found that his program in science was “cut-throat”, and that there was just “not a lot of co-operation”. He discussed that although students in his science program would occasionally work together on individual assignments, in engineering, *“I rarely heard a single [engineering student] who was like ‘I did that quiz or assignment on my own.’”* This was a key component to his transfer in, and fit within engineering, suggesting that, *“working in groups on academic things is a means of social interaction, which is something I just enjoy”*.

Sarah suggested that that this prevalence of group work was valuable: *“With the course [APSC] 480 (a multidisciplinary capstone design course), there’s... group work, [which] sets you up better for something you might be doing in the future.”*

5.2.3.2 Practicality

Participants valued the practical nature of engineering and their ability to apply their knowledge in various courses of instruction.

Andrea pointed out an important difference between science and engineering teaching methodologies:

“[in science] it was much more memorize and know it, but don’t understand it? But like in engineering, I found the focus is much more ‘build from the bottom up’, and ‘understand what’s going on’. Which I really like, and makes a lot more sense to my way of learning.”

The confluence of Andrea’s preferred method of learning and teaching styles in engineering seems to drive her satisfaction with the engineering program.

Cameron suggested: *“it really was an issue in comparison [with] engineering... that [in the science program] we weren’t learning much application.”* He acknowledged that engineering courses related more closely to his practical interests: *“I like to fix things and tinker, and that was just something that appealed to me”.*

Paul’s preference for practical learning was established in secondary school: *“In high school, I guess my favourite courses were programming, and things like that, because you could actually have something at the end and be like: ‘here, look at this! I made this thing by myself!’”* During his time at Queen’s, Paul transferred between engineering disciplines—from Electrical Engineering into Engineering Physics—based on this preference:

“Especially this one course, electronics. Um, like I really felt like I could have learned a lot, but by the end, I really came up with nothing. Like if you were to ask me to build an amplifier, at the end of the course—which is something that I think we learned, but if you were to ask me right at the end of the course: ‘can you do this for me?’, I would

probably say no. Like if you showed me a diagram, and asked me which—and you gave me the variables and everything, I could probably work out a number for you, but in terms of actually building it from the ground up, um, I don't think I would have gotten that experience from that course.”

Paul later discussed his time in Engineering Physics differently: *“it's definitely been very theoretical, which is I guess something that I enjoy. But... when they've promised it to be practical, it's been practical [which] is much appreciated.”*

5.2.3.3 Problem Solving

Problem solving is an important skill for professional engineers, and this is largely reflected in engineering programs. Many participants specifically identified this focus on problem solving as important to their satisfaction in engineering, as well as in various past-times.

Matthew explained his enjoyment of problem solving: *“I really like having—regularly having problems to solve... it's almost like a game.”* Sarah spoke in the same vein, likening the problem solving in engineering to a favourite past-time: *“On my iPad, all the games I have are like mystery game, and like clue games and stuff.”*

Cameron related the engineering program to book of puzzles that he enjoyed when he was growing up. He further generalized this into his mindset that *“solving puzzles is fun”*. During his youth, he spent time with his cousin on hobbies, and specifically mentioning that they made a potato cannon. Cameron emphasized problem solving as his favourite part of the process: *“When it broke, troubleshooting that, and fixing it, figuring out why it broke: that was... more fun for me than building it.”*

5.3 Practical Benefits of Engineering Programs

Each participant identified practical benefits as reasons for entry into the engineering program. Two practical benefits were especially identified: Degree Versatility and Directness to Workplace. Another three factors were identified to a lesser degree: Personal Change/Growth, the Engineering Job Market and Support from Others.

5.3.1 Degree Versatility

All seven participants identified Degree Versatility as an important feature of the engineering program.

Jeremy transferred from Chemistry into Engineering Chemistry for the expressed purpose of job options after graduation. In Jeremy's words, engineering "*opened more doors than say my previous program (chemistry)*". He found this freedom valuable later when he made some personal realizations:

"I don't believe that engineering itself is something I see myself doing later on, so I'm not super into the idea of going out and working for say, Shell in the oil fields and doing technical engineering stuff... it's something that doesn't really appeal to me."

He later explained that his understanding of this versatility was previously unknown: "*I saw engineering as strictly doing engineering in the most traditional sense of the word, whereas, there is consulting, all sorts of different career paths that I didn't know about before.*"

Management consulting was also mentioned as an option by Matthew, as it fit with his understanding and enjoyment of problem solving:

"A place that I discovered, a couple of days ago, because I was looking up the Kepner-Tregoe analysis, for one of my 218 labs, is Kepner-Tregoe, which they're consultants and they deal with problem solving together. Their motto is 'complex—clear thinking for a complex world'. And so, that's really interesting, so maybe I'm going to see about working there, because that's really cool. I don't know why, but I find that very interesting. So maybe that, or some kind of engineering thing."

Kepner-Tregoe is a management consulting firm—a distinct departure from a traditional engineering path [34].

Cameron similarly showed interest in business-related careers: "*Through what I've done, had experiences, now I'm looking more at the business management side as a career path, of you know, project management, or something in that sense.*" Cameron also demonstrated interest in potentially rejoining his initial academic path of medicine: "*Whether it was go and teach, continue getting a*

masters/PhD, and then just kind of stay in academia, and continue along that path... or go to medical school, probably in surgery. It's still something I haven't ruled out yet."

Paul and Sarah, both in the final year of their degree, indicated that they had already secured computer-related jobs at financial institutions. Paul accepted a job offer in an IT department. In his words,

"I guess IT is closer to the computing side of my degree... I think that's kind of where I'm going to try to stay? I guess going through [Engineering Physics] was fun, but I realized that I can learn physics, but I don't think I [would want to] be a physicist."

5.3.2 Directness to Workplace

Participants commonly contrasted engineering and arts/science educational paths by length. Thomas spoke to a common perception among participants that an arts or science bachelor's degree has limited value without further study:

"I found that upon looking to graduation as a science student, you end up a Bachelor of Science degree holder, and in this world, and in the time we live in, that is not worth nearly as much as it used to be, and the options to go from there include almost exclusively [graduate] studies. There aren't many professions that lend themselves well to just incoming bachelors of science degree holders."

Sarah showed a similar thought pattern: *"I'd have to get a masters or have to, you know, become a doctor or something. And from engineering, you know you can go out and get a job right away, it's already a profession. So that was definitely a draw."*

Cameron discussed this principle in contrast with engineering bachelor's degrees:

"I didn't want to stay in university quite that long... it's incredibly common for engineering, it's almost standard [that] you do your undergrad and then you get a job. Whereas, with the sciences, generally, you do your undergrad, at least your masters, sometimes a Ph.D., before you can really start adding to your field, whether it's in a job or research position. Whereas in engineering it seems like you can kind of do that right out of your undergrad, so to me it was less time – I won't say wasted – but it was almost a more efficient use of time."

Cameron made it clear that degree length was a key component in his transfer to engineering. Cameron, like others, extended his graduation by one year to transfer into engineering, and this shortening of his *total* academic career length acted as a motivator for his transfer. Jeremy also discussed this rationale as a part of his decision to transfer, saying:

“I could look at the fifth year [of my degree] saying ‘that’s one year out of the workplace’, but if I stayed in Arts and Science, realistically, I would have to do a masters, and that would have an associated cost, so that that’s kind of how I would justify myself.”

Andrea, despite selecting engineering initially, suggested that she also valued this flexibility:

“Um, like I’m definitely considering doing a masters after, so I don’t think the four year degree thing played that much of a role, but the fact that if midway through university, I decided I’m done with school, like I don’t want to do anything after, I don’t have to do a masters or a Ph.D.”

5.3.3 Personal Change/Growth

Participants identified an additional source impetus to transfer: they indicated personal growth, and thereby changing personal needs, which were no longer addressed by their former program.

Cameron personal change relates directly to discussion in the previous section (5.3.2), in that early into his university career, he realized: *“I’m not the biggest fan of... being in school”*, which incentivized his transfer into engineering, shortening his expected total duration in post-secondary studies. Cameron also re-established his enjoyment of physics, his distaste for which lead directly to his selection of biology and chemistry instead of his planned route of engineering, as discussed in Section 5.1.1.

Thomas pointed to a *“quarter-life crisis”* as the driver of his transfer, where he similarly found that he was no longer as interested in biology and chemistry as he once was.

Matthew initially selected Classical Studies as his major, due to his interest in the subject matter.

Although his interests did not change, his philosophy on his studies changed, deciding to satisfy his logical tendencies through engineering, and his artistic tendencies through extra-curricular activities.

Matthew explained:

“I also still find time to pursue my other interests at a level which I find satisfying, so I can still go to the music club every now and again, and bang out a rhythm on the drums, or write a poem, or go to the poetry slam... I wouldn’t find [engineering] a good fit if I didn’t do any of the other stuff. Being able to fulfill those interests and still do engineering, I think that’s kind of the happiest I can probably be in this environment.”

Personal change was indicated to alter program fit, and disputes the assumptions in the model proposed in Section 0. The model was ultimately improved to include personal change as a factor, as discussed later in Section 6.3.

5.3.4 The Engineering Job Market

The engineering job market was seen to be attractive by participants for the reasons of: relative job availability and high salaries. Thomas described engineering as: *“a program that offered a definitive and concrete endpoint: being an engineer, and having that career option... I’m a practical person, and I wanted to leave school secure—and in some professional capacity.”*

Matthew referred to engineering as a career that could, “make me money” and, “pay for my expensive tastes”. He further compared engineering careers with the types of careers he would have had access to with his initial program selection: *“There [are] no jobs in classics, and even fewer for linguistics!”*

5.3.5 Support from Others

Jeremy initially indicated that his family members who had been in engineering worked to dissuade, as discussed in Section 0, above. Conversely, Jeremy later suggested that his father approved of his transfer into engineering despite ‘losing’ a year of study.

Matthew identified three separate reasons for his transfer, two of which were based on real or perceived support of others:

“I’m not ashamed necessarily of this, but it’s probably the least, sort of, proud reason behind my change to engineering, and that is: I was trying to impress a girl, in first year who was in engineering. Um, she was in her second year, so that was maybe 30% of my decision to switch [laughs]. And the other 70% was like—like another 30% was to impress my parents, and the other 40% was like, you know, this is probably something that will probably benefit me more at the end of the line.”

This quotation served as a powerful reminder that each participant’s story is unique, and that every effort should be taken in qualitative research to draw out these highly personal details.

5.4 Transfer Considerations and Impacts

Since the majority of the interview participants had transferred into engineering, and many of the questions were related to their transfer, data was collected on the transfer process. Although the transfer process is not central to this study, the data was analyzed alongside the data presented in Sections 5.1 through 5.3. Two categories were established from this data: Negative Impacts and Institutional Support.

5.4.1 The Negative Impacts of Academic Transfer

None of the six interview participants who underwent an academic transfer (between faculties or disciplines) expected to complete their undergraduate degree within four years of their initial acceptance at Queen’s. All five of students who made a transfer between faculties did so after one year of their initial program, and except for Cameron and Jeremy, effectively restarted their degree, due to the low transferability of their credits. These three remaining participants were forced to apply to the Queen’s

Engineering program through OUAC, effectively re-enrolling in engineering as if they were applying directly out of high school.

Cameron realized especially early that he wanted to transfer, and gained entry to linear algebra for engineers, a course highly relied on as a prerequisite. This allowed him to apply directly to mechanical engineering, unlike the other transfer students. Upon acceptance, Cameron took a combination of first and second year courses, taking some extra credits during his summers to catch up. He suggested that he could have graduated in a total of four years, but decided to stay for a fifth. He declined to explain this decision.

Extending their graduation date obviously cost students both time and tuition, but it also caused social strain. Matthew found that his first year of engineering was difficult because as a second year, he lived off-campus, suggesting: *“I wasn’t in [residence], so I didn’t have the sort of support network that a lot of first year engineers have.”*

Paul described the difficulty generated by his friends graduating prior to himself: *“In previous years, you look forward to seeing everyone, and then this year, when I came back, it’s a lot less people that I’m going to be able to see.”*

Sarah described her similar situation more bluntly: *“[I] definitely notice [my transfer] more now, because everybody I did know isn’t here anymore.”*

Fortunately, Cameron anticipated these issues and proactively prevented them:

“I ended up doing frosh week [as a second-year], really as a means to get to know people. So, because of the chance I’ll have class with people in first year, so I would really like to know these people, not just be some random dude coming in that no one knows. And then also another part is the fact that, um, one thing that let me know more people was my involvement. I ended up getting on FREC committee to plan frosh week [the next year].”

From this, it can be ascertained that although social difficulties are a common pitfall of transfer students, they are avoidable.

5.4.2 Institutional Support of Academic Transfers

Participants described varying levels of reliance on institutional support in making their academic transfer. Jeremy indicated that he got help directly from the undergraduate coordinator for Chemical Engineering and Engineering Chemistry, who he suggested was “*super helpful*”, advising him to take linear algebra to ease his prerequisites once in engineering. She further suggested how he could most easily navigate his course requirements, and helped him organize his schedule throughout the rest of his degree.

Paul and Sarah each had some contact with undergraduate coordinators in their disciplines, but did not discuss further help once they had entered.

Matthew demonstrated a very different philosophy toward his transfer. He elected not to make any direct contact with program coordinators, and just applied to first year engineering with his high school marks, suggesting:

“I hate red tape and bureaucracy... it makes me anxious, so I kind of just decided to do the thing that would do for certain would give me the least—the least hurdles to deal with.”

Chapter 6

Discussion

This chapter will compare and contrast the data from Chapters 4 and 5, discuss how the themes identified affect the model established in Section 0, and explore the quality of data gathered, along with its limitations.

Themes identified in Chapters 4 and 5 were categorized by their relevance to the Research Questions, and logically connected where possible. These themes that were derived were also compared to expectations from the literature, where those expectations existed. Further themes that were identified, but are not directly related to a Research Question will be discussed in Section 6.2.

6.1 Revisiting the Research Questions

The Research Questions were established early in the study, and have served to guide the study throughout its duration. Both data collection tools were developed with the intention to investigate these questions from a variety of perspectives, as well as explore potentially important factors that may previously have been unidentified. The research questions were initially introduced in Section 3.1.

6.1.1 Research Question #1: Factors for Selecting Engineering

Research Question #1 asked: “What factors cause students to select engineering?” This was asked of participants directly through Question 5 in the survey and facets of it were examined in further detail throughout the rest of the survey, as well as in the interviews.

6.1.1.1 *Personal Interest*

In Question 5, ‘Personal Interest’ was the most highly selected factor, chosen by 72.4% of participants. This is consistent with Seymour and Hewitt (1997), which states that program interest is a factor in selection [35]. Personal interest is a very subjective factor and its selection can indicate a multitude of

different elements. In the interviews in Part B, participants suggested that more specific interests in problem solving, hands-on work and technology lead them to select engineering, which served to question the strength of ‘Personal Interest’ as a single explanatory factor. These identified values are further discussed below in Section 6.1.1.1, and the refinement of Question 5 is discussed in Section 8.4.

This finding corresponds with Heilbrunner (2011), where participants rated ‘interest in the topic’ as the most influential factor in program selection among college students [36].

6.1.1.2 Strength in Prerequisites

‘Strength in Prerequisites’ was indicated by 66.7% of participants, second only to ‘Personal Interest’. This large proportion was expected, because high marks in prerequisite courses are required for entry to the engineering program. In fact, this selection was different from the others in that the existence of success in prerequisites can be logically confirmed. Instead of asking whether the *premise* existed, the ‘Strength in Prerequisites’ checkbox was asking whether the existing premise of high marks *affected* program selection. This differs from a selection of ‘Extra-Curricular Activities’, to which a participant may have been completely unexposed.

A significantly larger proportion of female participants selected ‘Strength in Prerequisites’ than male participants, but there is little evidence to suggest why this is the case.

6.1.1.3 Knowing an Engineer

‘Knowing an Engineer’ was offered as an option in Question 5, and was selected by 40.1% of participants. Participants were also asked to indicate whether they personally knew an engineer prior to their application to university. 69.7% of participants indicated that they knew an engineer, while 24.5% indicated that one or both of their parents are engineers. With no ‘control’ survey or data available on the personal relationships of non-engineering students (or the general population), it is difficult to claim definitively that more engineering students knew engineers prior to application.

Looking at the proportion of engineering students with fathers in engineering is much more clear-cut. According to Engineers Canada, there are 280 000 engineers in Canada, equating to less than 1% of the population. The vast difference between this proportion and the 24.5% of students who indicated that their parent was an engineer strongly suggests a correlation between having parents in engineering, and going into engineering oneself. This is corroborated by this study's finding that 84% of those with a parent in engineering suggested that 'Knowing an Engineer' was a factor in their program selection. These statistics with Astin & Astin (1992), which suggested that having a father as an engineer was a factor in engineering recruitment [3]. This study did not mention the effect of having a mother in engineering, likely due to the lesser presence of women in engineering at the time.

Astin & Astin (1992) did not suggest a mechanism for this phenomenon [3]. One possible explanation proposed in this paper was that students with parents as engineers, or who knew engineers at all, were more likely to know about the engineering profession and program, and for this reason were more likely to select it.

6.1.1.4 Knowledge of Engineering Programs and Profession

Data from Question 8 was analyzed, looking at how much participants knew about engineering currently, and prior to program entry, based on whether or not that student knew an engineer prior to entry. The data supported that students who know an engineer prior to entry knew more about the engineering profession, but did *not* know more about the engineering program.

This pair of results indicates that, to some extent, those who are considering engineering interact with current engineers, but that the information that is transferred tends to relate to the engineering profession, and not the engineering program. It would seem logical that engineers are more comfortable discussing the engineering profession, which they are currently a part of, as opposed to engineering programs, which could have changed since they were enrolled. Engineers are also likely aware that engineering programs vary between schools, and for that reason be uncomfortable speaking about any specific program.

The effect of knowing an engineer was investigated in Part B interviews and a variety of different effects were identified, as discussed by three participants in Section 0. Cameron identified with the engineering profession through hobby projects with his cousin, who was an engineer. Jeremy suggested that his father, who is an engineer, pushed him away from going into engineering, but was later supportive of his transfer into the engineering program. Andrea was directed to specific engineering programs based on the research and guidance of her grandfather, an engineering professor, who was naturally closer to engineering programs than a typical practicing engineer.

These varied stories help paint a picture that interactions with professional engineers are naturally diverse in nature and outcome: although many of these interactions persuade students to enter engineering, others do not.

Question 11 attempted to gauge participants' understanding of engineering, by asking 'What is the role of math and science in engineering?' The validity of this evaluation is debatable, but one interesting finding came out of it: responses did not change by year, as indicated in Section 4.2.8. Given establishment of this evaluation as reasonable, this would indicate that with respect to the purpose of math and science in engineering, there was little evolution of understanding.

6.1.1.5 Vocational Factors

Vocational factors such as ease of finding employment and direct entry to workplace were indicated as important to the selection of engineering programs, through the 'Other' checkbox in Question 5, as introduced in Section 4.2.1. Despite the lacking a provided 'checkbox', 34 respondents (8.2%) indicated that it was an important factor. This is likely an underrepresentation of participants who would have selected it, had it been offered directly through a checkbox. This suggests a notable level of importance, despite the smaller proportion of participants that selected it compared to other factors.

A trend presented in the gender proportions of those who indicated that 'Vocational Factors' were important. They were indicated to be a factor by 26 or 10.6% of males, and 8 or 4.8% of females. This

difference was found to be statistically significant. Although this trend was somewhat clouded as discussed above, it appears to indicate one of the few gender differences found in this study.

The closest comparison that can be made with the literature is in Sheppard (2010), where first years and fourth years were asked to identify their motivations to study engineering [22]. Although there was no exact match, 'Vocational Factors' were most closely represented in Sheppard (2010) by 'Financial Motivations' [22]. There was no significant difference found between males and females among first years or fourth years in 'Financial Motivation' [22].

6.1.1.6 Teachers vs. Guidance Counsellors

Teachers and guidance counsellors work in parallel in secondary schools in Ontario. Teachers are primarily responsible for subject-teaching and evaluation, while guidance counsellors are primarily responsible for academic direction and guidance of students through secondary school and in preparation for further education and careers. A significant difference was found between the effect of teachers and guidance counsellors on students who entered engineering, as teachers were indicated as a factor by 22.4% of participants, while guidance counsellors were indicated by 9.1% of participants. Two factors may account for this: teachers spend more time with students overall, and that subject teachers in science may have more of an opportunity to discuss scientific careers.

This findings showed similarity with those of Paa & McWhirter (2000), which also suggested a greater perceived program selection influence from teachers than from guidance counsellors [37].

6.1.2 Research Question #2: Factor Links with Satisfaction

Research Question #2 asked: "What relationship do [program selection] factors have with program satisfaction?" A correlation table was used to compare the relationship between satisfaction, as gathered from Question 7, and the other survey variables, as can be found in Section 4.3.

Two variables showed 'small' correlations with the satisfaction variable: Likelihood of continuing to an engineering profession, and personal interest as an important factor in selecting engineering.

The correlation between satisfaction and ‘Likelihood to Continue’ show commonality with assertions of Schertzer & Schertzer (2004) which suggest links between student satisfaction and retention [7].

Likelihood to continue on to an engineering degree is not identical to satisfaction, but are intrinsically linked.

The correlation between satisfaction and personal interest draws similarity with Seymour (1997) which suggests that personal interest in subject matter is linked to retention [35]. This indirectly links satisfaction with personal interest, through satisfaction-retention links discussed above, and in Section 2.4.

6.1.3 Research Question #3: Reasons for Transfer into Engineering

Research Question #3 asked: ‘Why do students transfer into engineering from other programs, and what lead them to their initial non-engineering selection?’, and was mostly examined through the interviews in Part B. This section will discuss the themes that evolved out of the interview data, as well as connections to the survey data from Part A. Primary analysis of the data can be found in Chapter 5.

6.1.3.1 Social/Cultural and Academic Values

Many of the primary factors for transfer into engineering indicated by interview participants were social/cultural and academic values, which participants held in common with the engineering program.

The classification of ‘values’ in this context is not based in literature, instead evolving as a description of the data gathered from interview participants. Having only identified these themes after the completion of the surveys in Part A, there is no directly applicable quantitative data, although moving forward, this presents an important opportunity for study, as will be discussed in Section 8.3.

Participants usually came into contact with these values through their peers, early on in their post-secondary career, and personally identified with them.

Social/Cultural values were identified as involving the culture of engineering students, faculty, and traditions, but distinct from academics. It was suggested by one participant that engineering ‘jackets’, which are highly identifiable and commonly purchased by engineers in first year, were an important

motivator to transfer, as well as the rigorous engineering orientation week. Two participants further suggested that they expected engineers to be less social and have low social standing, later evaluating this not to be the case.

It is difficult to determine the source of this antisocial image of engineering students, but it may be in the interest of engineering programs to alter it. The engineering program at Queen's seems to successfully combat this image to some extent through its visible traditions and culture, but these traditions may have little visibility with secondary students, as no participant indicated any knowledge of it prior to entering Queen's.

Academic values were also commonly indicated to be factors for transfer into engineering. Each participant indicated that at least one of the following factors was important to their transfer: cooperation and group work; practicality; and problem solving. These three values are generally common across engineering programs, and yet many of those interviewed entered another program while unaware of them, despite necessarily having a background in science. This fundamental misunderstanding of engineering programs prior to entering university was highly identified, and is oddly unrepresented in the literature.

6.1.3.2 Practical Reasons for Transfer

Interview participants also discussed practical reasons for their transfer into engineering, largely due to vocational factors. As discussed above in Section 6.1.1.5, 8.2% of students surveyed indicated that vocational factors were important to their program selection, although this result is likely skewed low due to the fact that these answers were submitted through an optional text box. Later, those who had already indicated that they had transferred into engineering were asked to select why they did so, as introduced in Section 4.2.7. Of the students who transferred into engineering from another faculty, 19 of 21, or 90.5% indicated that 'Career Options' were an important factor in their decision to transfer.

Participants readily identified career versatility as an important feature of the engineering program, and suggested that this flexibility was previously unknown. After their engineering degrees were complete,

each of the seven participants anticipated options such as graduate school, medical school, business, management consulting, information technology and financial analytics. This theme of degree transferability is not often addressed in secondary school, nor in university. Two interview participants also identified the engineering job market as desirable, and this worked as incentive for their transfer. The relatively brief pathway to the workplace through engineering was indicated to be a draw by five of the seven interview participants. Participants suggested that they viewed graduate degrees as essentially obligatory for progression in non-engineering scientific fields, and they valued the option to be able to enter the workforce after a four-year degree. In fact, each student who underwent an academic transfer ended up extending their time at university by one year to complete their degree. For two participants, this perception that they would not need an additional degree to enter the workplace helped them rationalize this inefficiency.

This suggests that a student's preferred length of academic path is an important consideration when selecting a degree program, and that many find value in the relatively short professional degree path that engineering provides.

6.2 Additional Themes Identified

Due to the exploratory nature of this study, it was important to examine the data from as many perspectives as possible and search for patterns and themes that weren't directly related to the research questions. Engineering education research is in its infancy in Canada, and any additions to the field can be valuable. With this in mind, and with the intention of informing future study, this section will present various trends and themes that were identified.

6.2.1 Mother and Father as Engineers

A trend was detected in the data from Question 6 of the survey, through general descriptive analysis. Of the 25 participants who indicated that their mother is an engineer, 19 participants *also* indicated that their father is an engineer—a rate of 76%. This trend implies that female engineers ‘partner’ with male engineers at a very high rate.

The closest comparison available was provided by an analysis of the 2012 American Community Survey conducted by the US Census Bureau, which indicated that in the category of ‘Architecture and Engineering’, 22% of females marry males also in that category [38], [39]. The inclusion of Architecture professionals in this statistic reduces its relevance, as well as the fact that it relies on marriage, and not the siring of children, excluding families with non-nuclear configurations. Regardless of these distinctions, there is a vast disparity between the 22% from the literature and the 76% found in this study.

6.2.2 High Levels of Satisfaction Reported

According to the results from Question 9, 52.5% of students indicated that they were ‘Very Satisfied’ with their decision to enter engineering, while a further 37.3% indicated that they were ‘Satisfied’ with their decision. This left only 10.2% of students in two ‘negative’ categories: ‘Unsatisfied’ and ‘Very Unsatisfied’. This result was higher than expected. There was also no significant variation detected by year of study or gender, which shows that none of these groups are particularly satisfied or unsatisfied with their selection of engineering.

A measure of overall satisfaction was calculated in Sheppard (2010), through a four-point Likert scale that was then normalized, then converted to 0-100 [22]. Sheppard (2010) reported significantly ($p < 0.001$) higher satisfaction from first-year students (78.3) than from fourth-year students (71.3) [22]. A score of 78.6 was calculated from the survey results in Part A, which is very similar to Sheppard’s (2010) evaluation of first-years, while higher than its evaluation of fourth-years [22]. It should be noted that Part A did not include first-years, only second- to fourth-years.

6.2.3 Grade 10 Career Studies Course Ineffective

In the interviews in Part B, multiple participants indicated that their time in their mandatory Grade 10 Careers Studies class were poorly executed and failed to introduce scientific fields successfully. This was also reflected in the low proportion attributed to ‘Guidance Counsellors’ in Question 5 of 9.1%, because guidance counselors are generally responsible for teaching Career Studies courses. Participants commonly mentioned that online career direction quizzes were commonly used as a tool, finding them both inaccurate in retrospect, and insufficient. Participants especially suggested that these online quizzes failed to take career and lifestyle goals into consideration. This suggests a failure of curriculum and/or implementation of said curriculum 4-7 years ago, when these participants were high school students. This may still be the case, as the ‘Guidance and Career Education’ curriculum document, which is mandatory for all Ontario ‘Careers’ teachers to follow, has not been updated since 2006 [33].

6.2.4 Negative Impacts of Transfer

Academic transfer is an innately inefficient and costly process, primarily for the student involved. Each of the six interviewees who made an academic transfer during their academic career, between disciplines or faculties, ‘lost’ a year of progress, and took, or plan to take five years to complete their degree. This was expected, but valuable to examine. A less obvious impact to students is the social disruption that was detailed by multiple participants. Being set behind their peers by a year made participants’ remaining time at school more difficult: especially when peers graduated, participants felt left behind. One participant effectively started first year, but unlike his new cohort, he had no residence-based peer group, which made that year difficult as well. The ideal solution is obviously to ensure that students like these selected engineering initially, and avoid these stressors. Conceding that eliminating program mis-selection entirely is impossible, barriers and costs of academic transfer should be reduced where possible.

6.3 Adjustment of the Theoretical Model

A theoretical model was introduced in Section 0, based loosely on the model proposed by Jurkowitsch (2006) [23], and adjusted to include ‘Information Gathering’ and ‘Program Selection’ steps.

One primary omission was identified in the logical flow of the graph, with the identification of ‘Personal Growth’ as a factor in ‘Fit in Program’, as identified in Section 5.3.3. This factor was then added to the model, as seen below in Figure 29.

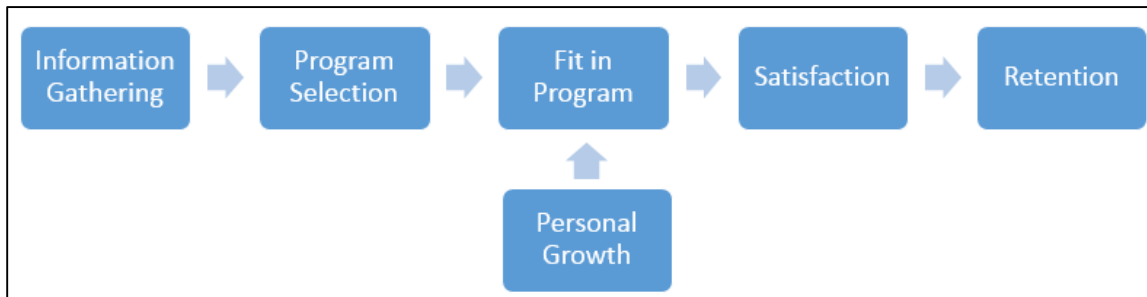


Figure 29: Adjusted theoretical model, with ‘Personal Growth’ added as a factor for ‘Program Fit’

This updated model provides a visual depiction of the process that a participant follows before and throughout their post-secondary career.

6.4 Limitations

There are many limitations of this study that must be addressed before the real-world applicability of the knowledge gained can be discussed. Of key importance, this was an explorative pilot study, designed with the primary intention of discovering themes and phenomena, to help direct future study.

6.4.1 Memory Bias

Parts A and B of this study were exposed to memory bias, due to the prominence of questions asking participants about their previous knowledge and motivations. This bias could be reduced by instead surveying and interviewing students who had recently made their program selection, but this study chose students later in their university career in the interest of gauging the changes in their perspective. Asking similar questions of these newer students would provide a value additional perspective to the field of study.

6.4.2 Queen's Engineering as Unique

The most immediate limitation of this study is that all of the data was gathered from the Queen's University Faculty of Engineering and Applied Science. Due to this local nature of the study, the findings from this study are not likely generalizable to engineering education globally, nor even in Ontario.

As discussed in Section 1.3, Queen's Engineering is unique in its history and programs, which along with its distinct retention and graduation rates, further decreases the likelihood of transferability. Expanding the sample of this study to other engineering schools would be an important step toward getting a full understanding of the phenomena studied.

6.4.3 Limitations of Survey

There was a crucial balance to consider when designing the survey. It was important to keep it as short as possible, in order to increase the uptake by both professors and students, seeing as they were giving up class time. Unfortunately, this limited many questions to a 'checkbox' style, which although were effective for providing descriptive statistics, were inflexible for use in modelling tools. Using Likert-scale questions for each item separately would have increased the richness of data, enabling factor analysis and logistic regression, as discussed in Section 4.3.1. Specific discussion of recommendations for future data collection tools can be found in Section 8.4.

6.4.4 Limitations of the Interviews

The interview portion of this study was focused on transfer students, and this group is relatively small. It was especially hard to find female interview participants, being an even smaller subset. There were only two female students interviewed, and one was the token non-transfer student, so the interviews were not reliably capable of extracting gender-specific data.

6.4.5 Limitations of the Researcher

I entered this Masters of Applied Science program directly out of my undergraduate engineering degree, at Queen's. Although this made me familiar with the Queen's Engineering program, as well as engineering principles in general, I started my degree with a weak knowledge of qualitative research.

After courses on quantitative and qualitative research methods through the Graduate School of Education during the first year of my degree, I was generally prepared to start my thesis work.

Designing this study was challenging, and some opportunities for improvement became apparent over the course of data collection. The interviews proved especially difficult to conduct at first, but as they went on, I became more proficient. I was also a novice at qualitative coding and analysis, but through iteration, I improved.

Overall, I put as much effort as possible into learning and practicing the techniques seen throughout this project, and hope that this thesis will provide useful findings, and successfully guides future projects.

Chapter 7

Conclusions

Undergraduate students at Queen's University were surveyed and interviewed to examine the factors behind engineering program selection and academic transfer to engineering. The surveys were completed by 416 second, third and fourth year undergraduate engineering students, primarily examining the reasons students chose to enter engineering, their demographics, their personal knowledge of engineers, and their understanding of engineering programs and the engineering profession. The survey was also used to recruit students who had undergone an academic transfer for interview.

Seven interviews were completed with these students, examining the reasons for their transfer, as well as the factors behind their initial program selection.

Four primary factors were identified as important to the selection of engineering programs: interest in the subject matter, strength in prerequisites, knowing an engineer, and vocational factors. It was found that knowing an engineer correlated with greater reported knowledge of the engineering profession, but *not* with a greater knowledge of engineering programs. It was further found that teachers were considered an important factor in program selection significantly more frequently than guidance counsellors.

Small correlations were found between two survey variables and satisfaction: likelihood to continue on to an engineering profession and personal interest in subject matter. 'Likelihood to Continue' is a logical result of satisfaction with the selection of engineering. The correlation between interest in subject matter and satisfaction can be combined with the finding listed above: interest in subject matter is both a reason students select engineering and a reason why students are satisfied with their selection. This presents 'personal interest' as a particularly valuable criterion for program selection, as was also suggested by the literature.

Reasons that students transferred into engineering were split between a similarity of values with the program and practical reasons. Social/cultural values were discussed, suggesting that students valued engineering traditions and that engineering students were more social than many applicants expected. Students further identified academic values that they shared with the engineering program: co-operation and group work, practicality, and problem solving. Understandings of these values were generally gained after they had entered Queen's, through peers already in the engineering program. Transfer students also addressed practical considerations: degree versatility, directness to workplace, personal change/growth, the engineering job market, and support from others.

In exploring the data, themes were discovered that were not directly related to the research purpose of the study. High levels of satisfaction were indicated by students, with 90% of students indicating that they were Satisfied or Very Satisfied with their selection of an engineering program. Overall levels of satisfaction (first-fourth years) were found to be similar to those reported in the literature by first year students, and greater than those reported by fourth year. Separately, in 76% of cases where a participant's mother was indicated to be an engineer, their father was also indicated to be an engineer.

This study helped to fill the gaps in knowledge, both in examining why students choose engineering in Canada, as well as why students who eventually transferred to engineering did so, and why they did not select engineering initially.

Chapter 8

Recommendations and Future Work

Due to the exploratory nature of this study, its primary goal was to augment the field of knowledge, as opposed to identifying concrete recommendations for future practice. In many ways, this study raises more questions than answers. These questions can provide future studies with direction and context. The field of knowledge would also benefit from growth of the study sample, and the further examination of newly identified themes.

Finally, this chapter provides a practical discussion of the instruments used, which should aid in the design of future studies.

8.1 Principles for Guiding Students in Secondary School

Four factors were commonly shown to be important to selecting engineering, but only one was seen to have further correlation with satisfaction: personal interest. With student satisfaction as a goal, this combination of findings behooves those directing students to engineering to do so primarily because of their interest in the subject matter.

Through the interviews, it became apparent that for each of the transfer students, the match between their values and the values of their program were very important. These participants consistently learned about these values from their peers who were currently in engineering, not having learned of them prior to entering university. Exposing students to these values prior to their entry decision could help guide more students to engineering, and increase the likelihood that they fit well into the program. To simulate the peer-to-peer information transfer prevalent at university, more secondary school students should be exposed to current engineering students through classroom visits or otherwise.

Secondary school students should also be exposed to the practical benefits of engineering, as discussed by transfer students in Section 5.3. Students transferring into engineering valued the versatility of an

engineering degree, the 4-year track to the workplace, and the strength of the engineering job market. It is logical that secondary school students may also value these aspects of the engineering academic path.

8.2 Enlarging the Data Set

This study was intended to serve as a pilot for a wider roll-out to more engineering institutions. This would be beneficial for many reasons. It would lend further credibility to the findings, allow the findings to be more widely transferable, determine if there are trends across provinces or nationally, and allow the researchers to effectively compare the population at Queen's to those at other schools.

8.3 Phenomena to Investigate Further

This study came across multiple pieces of information that it was not specifically looking for, which would significantly benefit from further investigation.

It was found through Question 6 that ~70% of participants knew an engineer before applying to university. Although this seemed high in the context of the research, it is difficult to know what proportion of non-engineering students knew an engineer before they applied to university. Acquiring this statistic through study would provide context.

About 25% of students indicated that at least one of their parents was an engineer, which contrasts distinctly with proportion of Canadians who are engineers (~1%). Some mixture of genetics, parenting and personal influence are likely responsible for this discrepancy in some capacity, and further research should be undertaken to better understand the interplay of these factors.

In Section 0, it was discussed that 76% of participants who indicated that their mother was an engineer, also indicated that their father was an engineer. It was suggested in that chapter, that this may be a 'legacy' effect, but further evidence is required to properly understand this phenomenon. It would also benefit from similar surveying at other institutions and/or a direct survey of current female engineers themselves.

Identifying the importance of academic and social/cultural values to students also provides an interesting opportunity for study. Determining the ways in which this knowledge of values contributes to selection

of, and satisfaction in, engineering programs could significantly aid in the design of new and more effective outreach methodology.

8.4 Instrument Refinement

Before further research is carried out, it would be prudent to refine various aspects of the two data-gathering instruments.

The most prominent refinement would be to augment Question 5 in the survey, adding an option for ‘vocational reasons’ or similar. The common use of this as a write-in option entered through ‘Other’ indicated that it should have been offered as an option. This would allow for better comparison with other factors. Checkbox selection was utilized for many questions in the survey in order to decrease survey completion time, but they proved overall to provide a limited quality of data. Replacing these checkbox inputs with individual Likert scale inputs would help dramatically. For example, Question 5, on reasons for selecting engineering, could be broken down into parts a) through g), each asking “How important was [a given factor] in your selection on engineering”, while also offering a ‘N/A’ option.

The survey also failed to capture participants’ method of academic transfer, when it took place, and whether they entered the open first year, or a specific engineering discipline.

Two interview questions also proved problematic: Questions 6.(a) and 7. Question 6.(a) asked participants “If you were able to go back to the time of your original entry decision, would you alter your choice?” This question did not often provoke useful responses, as some participants suggested that they wouldn’t change their trajectory because they wouldn’t risk altering the way that their university experience worked out. Others simply shrugged and suggested that it would obviously have been better not to ‘waste’ a year transferring. In essence, it did not achieve the suggested purpose “To get a sense of how the participant feels about their transfer.”

Question 7 asked students “Will your unusual path through university affect your career path after university?” This question was convoluted and consistently required clarification, and even when clarification was provided, did not yield any valuable results. This question should simply be eliminated.

Chapter 9

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Appendix A

General Research Ethics Board Approval



July 07, 2014

Mr. Jake Armstrong
Master's Student
Department of Mechanical and Materials Engineering
Queen's University
Kingston, ON, K7L 3N6

GREB Ref #: GMECH-028-14; Romeo # 6013106
Title: "GMECH-028-14 Investigation of the Causal Factors for Enrollment and Satisfaction in Engineering Programs"

Dear Mr. Armstrong:

The General Research Ethics Board (GREB), by means of a delegated board review, has cleared your proposal entitled "GMECH-028-14 Investigation of the Causal Factors for Enrollment and Satisfaction in Engineering Programs" for ethical compliance with the Tri-Council Guidelines (TCPS) and Queen's ethics policies. In accordance with the Tri-Council Guidelines (article D.1.6) and Senate Terms of Reference (article G), your project has been cleared for one year. At the end of each year, the GREB will ask if your project has been completed and if not, what changes have occurred or will occur in the next year.

You are reminded of your obligation to advise the GREB, with a copy to your unit REB, of any adverse event(s) that occur during this one year period (access this form at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Adverse Event Report). An adverse event includes, but is not limited to, a complaint, a change or unexpected event that alters the level of risk for the researcher or participants or situation that requires a substantial change in approach to a participant(s). You are also advised that all adverse events must be reported to the GREB within 48 hours.

You are also reminded that all changes that might affect human participants must be cleared by the GREB. For example you must report changes to the level of risk, applicant characteristics, and implementation of new procedures. To make an amendment, access the application at https://eservices.queensu.ca/romeo_researcher/ and click Events - GREB Amendment to Approved Study Form. These changes will automatically be sent to the Ethics Coordinator, Gail Irving, at the Office of Research Services or irvingg@queensu.ca for further review and clearance by the GREB or GREB Chair.

On behalf of the General Research Ethics Board, I wish you continued success in your research.

Yours sincerely,

A handwritten signature in black ink that reads "Joan Stevenson".

Joan Stevenson, Ph.D.
Chair
General Research Ethics Board

c: Dr. David Strong, Faculty Supervisor

Appendix B

Letters of Information and Consent

B1: Letter of Intent and Consent Form for Online Survey (Part A)

LETTER OF INFORMATION

“INVESTIGATION OF THE CAUSAL FACTORS FOR ENROLLMENT AND SATISFACTION IN ENGINEERING PROGRAMS”

This research is being conducted by Jake Armstrong under the supervision of Professor David Strong in the Faculty of Engineering and Applied Science at Queen’s University in Kingston, Ontario.

The purpose of this study is to understand individuals’ reasons for entry into the undergraduate Engineering program at Queen’s University, and their corresponding retention and satisfaction with the program. The research question driving this study is: “Why do students choose to enter engineering, and what relationship does this entry selection have with program satisfaction?” **It will take 5 minutes to complete.**

There are no known risks associated with your participation in this study. Participation is completely voluntary. You are free to withdraw at any time for whatever reason without penalty by just exiting the survey before the end. You are not obliged to answer any questions that you find objectionable. You will not be identified in any way if the results are published and nothing will connect you to your responses. All data will be stored in a secure computer file accessible only to the researchers until published, at which point the files will be erased from the computer.

The final section of the online survey will allow those who qualify to **optionally** submit their contact information, to participate in the second part of this study. This submission of contact information will in no way be linked to your survey responses. The second part of the study will involve a 40-minute interview, which will be both audio-recorded and entirely confidential.

Any questions about study participation may be directed to Jake Armstrong at jake.armstrong@queensu.ca or at (613) 876-4645 or his supervisor Professor David Strong at (613) 533-2606 or strongd@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at (613) 533-6081 or chair.GREB@queensu.ca.

This study has been granted clearance according to the recommended principles of Canadian ethics guidelines, and Queen's policies.

Thank you again for your participation,

Jake Armstrong - Graduate Student

David Strong - Faculty Supervisor

If you consent to participate in this study, click “Continue.” Otherwise, you may exit the study.

B2: Letter of Intent and Consent Form for Interviews (Part B)

Letter of Information

“INVESTIGATION OF THE CAUSAL FACTORS FOR ENROLLMENT AND SATISFACTION IN ENGINEERING PROGRAMS”

This research is being conducted by Jake Armstrong under the supervision of Professor David Strong in the Faculty of Engineering and Applied Science at Queen’s University in Kingston, Ontario.

What is this study about? The purpose of this study is to understand individuals’ reasons for entry into the undergraduate Engineering program at Queen’s University, and their corresponding retention and satisfaction with the program. The research question driving this study is: Why do students choose to enter engineering, and what relationship does this entry selection have with program satisfaction?

The study will utilize data from two sources: (a) 2nd-4th year undergraduate engineering students and (b) students who have transferred into or out of engineering during their undergrad career. The 2nd-4th year students will be surveyed on their reasons for entry into engineering, as well as their retrospective satisfaction with that choice. The transfer students will be interviewed about their reasons for entry into their initial program, as well as their reasons for transfer. Non-transfer students will also be interviewed on their reasons for program entry.

What will this study require? The interview portion of the study will involve the interview, especially focused on students who have transferred into or out of engineering during their time as an undergrad, but accepting all participants. The 40-minute interview will be entirely confidential and audio-recorded. Most participants will have been referred to this interview process by the final section of the online survey in part A.

Is my participation voluntary? Yes. Your participation is completely voluntary and choosing not to participate will not result in any adverse consequences. There are no known physical, psychological, economic, or social risks associated with this study. Further, you are free to choose, without reason or consequence, to refuse to answer any of the questions. You may withdraw from the study at any time with no negative consequences. If you withdraw from the study, you may choose to have your data removed and destroyed.

What will happen to my responses? Interview recording will be transcribed and then the recording will be destroyed. All electronic files will be password protected. Paper and audio data will be secured in a locked cabinet. I will maintain copies of the transcripts for a minimum of 5 years and may use the data (with names removed) in subsequent research. Confidentiality will be protected to the extent possible. None of the data will contain your name. To protect your identity a pseudonym will replace your name on all data files and in any dissemination of findings. This research may result in publications of various types, including journal articles or other professional publications.

What if I have concerns? Any questions about study participation may be directed to Jake Armstrong at jake.armstrong@queensu.ca or at (613) 876-4645 or his supervisor Professor David Strong at (613) 533-2606 or strongd@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at (613) 533-6081 or chair.GREB@queensu.ca.

Again, thank you. Your interest in participating in this research study is greatly appreciated.

This study has been granted clearance according to the recommended principles of Canadian ethics guidelines, and Queen's policies.

Consent Form

“INVESTIGATION OF THE CAUSAL FACTORS FOR ENROLLMENT AND SATISFACTION IN ENGINEERING PROGRAMS”

Name (please print clearly): _____

1. I have read the Letter of Information and have had any questions answered to my satisfaction.
2. I understand that I will be participating in the study called “Investigation of the Causal Factors for Enrollment and Satisfaction in Engineering Programs”. I understand that the purpose of this research is to gain insight on individuals’ reasons for entry into the undergraduate Engineering program at Queen’s University, and their corresponding retention and satisfaction with the program. I understand that my participation in this study will entail a maximum of 60 minutes of my time involving an audio-recorded interview.
3. I understand that my participation in this study is voluntary and I may withdraw at any time. I understand that every effort will be made to maintain the confidentiality of the data now and in the future. Only experimenters in the Engineering Education Laboratory will have access to this area. The data may also be published in professional journals or presented at scientific conferences, but any such presentations will be of general findings and will never breach individual confidentiality. Should you be interested, you are entitled to a copy of the findings.
4. I am aware that if I have any questions, concerns, or complaints, I may contact Jake Armstrong at jake.armstrong@queensu.ca; or his supervisor Professor David Strong at (613) 533-2606 or strongd@queensu.ca. Any ethical concerns about the study may be directed to the Chair of the General Research Ethics Board at (613) 533-6081 or chair.GREB@queensu.ca.

I have read the above statements and freely consent to participate in this research:

Please sign one copy of this Consent Form and return to Jake Armstrong.

Retain the second copy for your records.

Signature: _____ Date: _____

Appendix C

Data Collection Tools

C.1: Online Survey

Survey on Undergraduate Program Entry

20%

Demographic Information

1. What is your gender?

- Female
- Male
- Other (Please indicate)
- Prefer not to answer

2. In which year of your degree are you currently?

Please select the best answer

- 1
- 2
- 3
- 4+
- Other (Please indicate)

3. Are you an international student?

- Yes
- No

4. Which program are you currently in?

- | | |
|--|--|
| <input type="radio"/> Chemical Engineering | <input type="radio"/> Geological Engineering |
| <input type="radio"/> Civil Engineering | <input type="radio"/> Mathematics and Engineering |
| <input type="radio"/> Computer Engineering | <input type="radio"/> Mechanical and Materials Engineering |
| <input type="radio"/> Electrical Engineering | <input type="radio"/> Mining Engineering |
| <input type="radio"/> Engineering Chemistry | <input type="radio"/> Core First Year Engineering |
| <input type="radio"/> Engineering Physics | <input type="radio"/> I am not in an engineering program. (Please state program) |
-

Program Entry Data Collection

5. What would you consider were the most important factors that caused you to choose engineering?

Please select all that apply

- | | |
|--|--|
| <input type="checkbox"/> Personal interest | <input type="checkbox"/> Engineering/science outreach programs (Please State) <input type="text"/> |
| <input type="checkbox"/> Knowing an engineer | <input type="checkbox"/> Strong in prerequisite academics |
| <input type="checkbox"/> Teachers | <input type="checkbox"/> Other (Please State) <input type="text"/> |
| <input type="checkbox"/> Guidance counselors | <input type="checkbox"/> None of the above |
| <input type="checkbox"/> Extra-curricular activities | |

6. Did you personally know a professional engineer prior to applying to university?

Please select all that apply

- | | |
|--------------------------------------|--|
| <input type="checkbox"/> Mother | <input type="checkbox"/> Other relative |
| <input type="checkbox"/> Father | <input type="checkbox"/> Friend |
| <input type="checkbox"/> Sibling | <input type="checkbox"/> Other (Please State) <input type="text"/> |
| <input type="checkbox"/> Grandparent | <input type="checkbox"/> None |

7. Looking back, how satisfied are you with your decision to enter engineering?

- | | | | | | |
|----------------|-----------------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | Very Unsatisfied | Unsatisfied | Satisfied | Very Satisfied | N/A |
| 7. (See above) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

8. Please indicate your level of knowledge in the following circumstances.

- | | No Knowledge | Some Knowledge | Strong Knowledge | Complete Knowledge |
|---|-----------------------|-----------------------|-----------------------|-----------------------|
| a) How much knowledge did you have about the engineering program , prior to entering university? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| b) How much knowledge do you have about the engineering program currently? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| c) How much knowledge did you have about the engineering profession , prior to entering university? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| d) How much knowledge do you have about the engineering profession currently? | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

9. How likely are you to pursue a career in engineering?

- | | | | | |
|----------------|-----------------------|-----------------------|-----------------------|-----------------------|
| | Very Unlikely | Unlikely | Likely | Very Likely |
| 9. (See above) | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

Interfaculty Transfer

10a. Have you completed any academic transfers (inter-discipline, inter-faculty, and inter-university transfers) during your undergraduate degree?

Please select all that apply

- No, I have stayed in the same program throughout university (Will hide question 10b)
- Yes, I have transferred between engineering *disciplines* (e.g. Mechanical to Civil) during my university career
- Yes, I have transferred between *faculties* (e.g. Arts and Science to Engineering) during my university career
- Yes, I have transferred between *universities* (e.g. University of Toronto to Queen's University) during my university career

10b. What were the most important factors that led to your transfer?

Question hidden if "No, I have stayed in the same program throughout university" is selected in question 10a, above

Please select all that apply

- N/A
- Personal interest
- Knowledge gained about the engineering *program*
- Knowledge gained about the engineering *profession*
- Career options
- Academic difficulty
- Other

11. What is the role of math and science in the engineering profession?

Please select the best answer

Math and Science are:

- The focus
- A useful tool
- The heart and soul
- A necessary evil

12. Where and how did you get the information you used to make your initial program selection?

Optional

Please feel free to include any details or anecdotes that this survey may have missed

[Back](#) [Next](#)

Interview Recruitment

There is an *optional* second part to this study: a 40-minute personal interview. These interviews are confidential, and audio-recorded.

All data used for the study will be completely anonymous.

Students who have transferred during their undergrad are especially sought, but all participation is appreciated.

Are you interested in being interviewed for Part B of this study?

If so, please supply your email. You may drop out of the study at any time.

Note: Your contact information will not be connected to your answers in this survey in any way.

- Yes I am interested. Contact email:
- No, I am not interested

C2: Interview Guide

Interview Introduction

I am conducting a research study on why students to choose engineering programs. As a student who has transferred [into/out of] the engineering program, you have a unique perspective on this process.

I have a few questions to guide our conversation today. The interview should take about 40 minutes.

I'd like to remind you of 3 points from the Letter of Consent:

- Your participation in this study is voluntary and you may withdraw at any time. You are also free to skip any questions that you are uncomfortable answering.
- None of the data will contain your name. To protect your identity, a pseudonym will replace your name on all data files and in any dissemination of findings. Every effort will be made to maintain the confidentiality of the data now and in the future
- Should you be interested, you are entitled to a copy of the findings.

Provide contact information of the interviewer

I'd like to audio record the interview, so I can capture the discussion accurately and won't be scribbling notes while we're talking, is this alright with you?

Do you have any questions before we get started?

Part B Interview Guide

Question	Purpose of Question
1. What was your program choice upon entry to university, and what caused you to make that choice?	To get background information on the participant, and their initial program choices.
2. (a) Were you satisfied with that choice?	Timeline kept ambiguous in (a), to let the participant define the important moments in their reversal of choice.
(b) How has your satisfaction with that choice changed over time?	How long did it take to know that the participant wanted to transfer?
3. (a) When did you transfer into engineering?	To gain information on the actual transfer process and to examine the real-life cost of transferring between faculties during undergrad.
(b) How did the process work?	
(c) What was the cost to you in time and effort?	
4. (a) What were the reasons that you transferred into engineering?	What caused the participant's change of mind?
(b) Has [the new program] been a better fit?	Was is dislike/incompatibility with their initial choice, or attraction to their transfer-option?
5. Faculty transfer often represents a significant change in thinking. In what ways would you say that your perspectives on engineering as a program and as a profession have changed your initial program decision?	To place emphasis on the participants' changing perceptions of engineering as a program and profession.
6. (a) If you were able to go back to the time of your original entry decision, would you alter your choice?	To get a sense of how the participant feels about their transfer.
(b) If so, what information would have helped you make that preferred decision?	To take a guided look at what could potentially change the decision-making process of future students in the same situation.
7. Will your unusual path through university affect your career path after university?	To look at the long-term ramifications of their transfer, and how that will impact their future decision-making.

Is there anything else you'd like to add? Thank you very much for your time.