Understanding Opportunities and Barriers to Engineering Student Success and Persistence

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Abstract

The objective of this work was to determine what opportunities and barriers exist for University of Saskatchewan engineering students that may affect persistence and/or academic success. A systematic literature review analyzing factors impacting student retention and attrition provided a framework to guide this study.

As the factors identified by the systematic review include both cognitive and non-cognitive factors, a convergent mixed methodology study was chosen. Data was collected from a pilot survey, engineering student demographic databases, a final (full) survey, interviews, and a focus group to assess each factor in the framework. A pragmatic epistemological approach was employed, allowing the researcher to utilize constructivist and post-positivist stances as appropriate, based on the type of data collected/analysis conducted, with corresponding quality criteria indicated explicitly.

Upon completion of the convergent analysis of these data sources, the framework was corroborated, suggesting that the factors that impact student attrition/retention include: institutional climate, curriculum, mentorship, peer influence/sense of belonging, faculty engagement, student access to professional role models, a student’s academic achievement history, learning style, intrinsic motivation and attitude, self-efficacy, and demographics (gender, Indigenous ancestry, rural/urban, etc.). Those factors most pronounced in this study’s context were peer influence and sense of belonging, faculty engagement, and student workload/curriculum, and it is recommended that these issues are further investigated by the College of Engineering in order to identify what actions may be taken to optimise student experience with regard to these three factors.

Acknowledgements

I would like to thank the Gwenna Moss Centre for Teaching and Learning (GMCTL) for financially supporting this project in order to inform College of Engineering choices. This investment has already made an immeasurable impact on engineering student lives and hopefully this research will continue to inform the College in its decisions moving forward. The GMCTL representative, Dr. Carolyn Hoessler, was instrumental in the successful completion of this study and I am grateful for her mentorship along the way. I wish her all the best in her new role at Ryerson University.

I would also like to acknowledge my two supervisors, Dr. Sean Maw and Dr. Terry Fonstad, and thank each of them for providing me with different lessons and mentorship. Having two supervisors enabled me to learn from two very different people, and to mature/grow into a solid researcher and professional. Than you both for your time and commitment to this project, and for being pioneers in the relatively new area of Engineering Education within a Canadian context.

Many individuals have helped bring this thesis to fruition. In particular, I want to give a sincere and special thank you to Donna Beneteau and Shelley-May Neufeld, without whom this thesis would exist in a much poorer state, if at all.

Most of all, I would like to acknowledge the love and support that I've received from my friends and family, enabling me to continue on this path. Thank you for encouraging me, consoling me, believing in me, and for celebrating this accomplishment with me. Truly, I am a very fortunate person to have you all by my side.

Dedication

To my husband Evan, for being my best friend and most steadfast cheerleader in this endeavor. I am grateful to share this life with you, and look forward to our future together.

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1 Introduction

The *Engineers Canada Labour Market Report: Projections to 2025* highlights an expanding job market as a result of retiring baby boomers, giving engineering colleges in Canada the opportunity to provide graduates who are able fill this labour force deficit (Engineers Canada 2015). While engineering colleges can increase their graduate numbers through increasing student enrolment in their programs, there are facility and faculty constraints that will limit this strategy. An opportunity exists though, to increase the total number of graduates by retaining a higher percentage of each incoming cohort of engineering students.

Though the exact cost is difficult to discern, retaining college students is widely accepted as more cost effective than recruiting new students to fill seats that have been vacated (Grayson & Grayson 2003; Raisman 2013). When students drop-out of a college, they not only affect that college's financial health as a result of decreased tuition revenues, but the University's overall financial health through the loss of patronage to campus services and stores, residence fees, and future alumni donations (Raisman 2013). This lost revenue is incurred in addition to the university/college having to invest in the recruitment of new students, estimated at a cost of $536 per student for a four year public institution (Ruffalo Noel Levitz 2018). Publicly funded institutions are expected to consider their use of public funds in recruiting new students. In addition, it must be acknowledged that this ultimately results in the loss of a potential engineer to an increasingly technological society.

In addition to financial considerations, there is an ethical question of enrolling students into a program when they are not prepared to succeed. Doing so may impact a student's future educational prospects (particularly if they want to attend a different college or institution), and may also influence the reputation of the institution; "The loss of students returning to campus for another year usually results in greater financial loss and a lower graduation rate for the institution, and might also affect the way that stakeholders, legislators, parents, and students view the institution." (Lau 2003)

Many engineering colleges in North America have made retention a priority, especially for first-year students, to lessen the financial and societal cost of student attrition. It is clear that in the near future, more engineering graduates will be required to meet industry demand, and that these engineers will require more diverse graduate attributes to serve society and to thrive in the profession (Koenig et al. 2012).

1.1 Background

The profession of engineering has expanded and transformed with the advancement of technology and will continue to do so. At the same time, incoming engineering students will differ from previous generations of engineers both in how they learn and interact with new technologies, and demographically (Hope 2016; Seemiller & Grace 2017). It is imperative that engineering colleges evolve along with societal demographics and technological advancements, and while there are many programming efforts in Canada that aim to do this and to boost graduate numbers (particularly to increase student body diversity) in engineering colleges, there have been few studies that have looked at the complex interactions between factors that interact to encourage student persistence. There has also been relatively little research done in Canada in the field of Engineering Education (compared to US markets), and no peer reviewed publications have focused on retention specific to engineering students in Canada.

Engineering student cohorts differ from those of a typical university student as a whole, both demographically and in terms of what retention-programming interventions are found to be effective, including students from other STEM disciplines (Veenstra et al. 2008), (Peuker et al. 2015). This suggests that research focused specifically on engineering students is required to define their unique barriers and viable interventions. Though there is research that focuses on engineering student retention/attrition in the United States (used for this literature review), the generalizability of American research to the Canadian engineering education system has not been adequately verified.

The current graduation rate of The College of Engineering (the College) at the University of Saskatchewan is between fifty-five and sixty-five percent of each cohort based on internal reporting. In an effort to increase the total number of graduates, the College has recently added 150 seats to their first-year cohort (Makulowich 2018). Adding more water to a leaking bucket is noticeably more expensive than fixing the leak to retain more students. If the current graduation rate is maintained, it is possible that over 150 students out of next year's cohort will leave the College before their third-year. This large increase of students may also strain existing space availability, student support staff, and faculty if they do not see a corresponding increase in resources.

1.2 **Objective**

The objective of this work was to determine opportunities and barriers that exist for engineering students at the University of Saskatchewan that have the potential to impact student persistence in the College and/or academic success. After ascertaining which factors affect the retention of engineering students, strategic interventions are recommended to improve the retention rate in the College.

1.3 **Scope**

The following data were collected and analysed within the scope of this study, and are discussed in the methodology and results chapters to follow:

- Binary logistic regression analysis using engineering student enrolment data from 2005-2015 using high school grades as independent variables and retention as a dependent variable;
- Linear regression analysis using engineering student enrolment data from 2005-2015 using high school grades as independent variables and a student's sessional weighted average at graduation as a dependent variable;
- The creation and dissemination of a pilot survey aimed at assessing barriers to student success and retention and descriptive/inferential analysis of this survey;
- The creation and dissemination of a primary (full) survey;
- Descriptive and Inferential statistical analysis of both cognitive and non-cognitive variables from the full survey;
- Thematic analysis of open-ended survey questions;
- Interviewing five students who fell below the promotional standard of the College in their first semester of the engineering program;

- Facilitation of a focus group with 5 students in the top 5% of their engineering class after the first semester of the engineering program;
- Thematic analysis of individual interviews and the focus group.

1.4 Researcher Positionality

I belong to the same social group as I intended to study, and am therefore an “insider researcher” as defined by Bonner and Tolhurst (2002). I received an undergraduate degree from the College of Engineering (the College), I conducted this research as a graduate student within the College, and I worked full time as an academic advisor within the College during the data collection and analysis phases of this study. Throughout my time in the College, I have had an interest in increasing minority group participation in the engineering profession.

Being an insider with ‘on-site availability’ made it easy to reach out to participants and schedule interviews and a focus group, and helped me to quickly build rapport with them in our interactions, as suggested by Platzer and James (1997) . As a graduate of the College, I have shared experiences with participants and a greater understanding of the culture in which this research was conducted (Pugh et al. 2000).

2 Literature Review

Despite the desire to increase student persistence and the need for more engineering graduates, there is little published research that looks at the issue comprehensively, accounting for all potential factors that may contribute to an engineering student's decision to stay or leave engineering majors. There are few peer-reviewed papers focused on engineering students specifically, although engineering students have been found to differ from even science major peers in terms of what causes them to leave their initial choice of college, and in terms of what interventions help encourage them to stay (Peuker et al. 2015).

In an effort to understand the wide array of factors that influence a college's retention rate, a systematic literature review was conducted using the *Preferred Reporting Items for Systematic Reviews and Meta-analyses* (PRISMA) systematic review guidelines (Moher et al. 2009). Though systematic reviews are vulnerable to publication bias (e.g. researchers tend to publish findings that infer a cause of student attrition more often than factors that do not cause attrition), it is considered an emerging best practice in the field of engineering education (Borrego et al. 2014).

Based on PRISMA guidelines, literature was identified through a documented funnel (Figure 2.1). Subsequent to this review process, an additional search was added using the qualifying terms "engineering persistence." These additional papers were included below, with no other factors being identified, only serving to bolster the findings from the original. After applying the limitations that: "engineering" and "attrition or retention" had to be present in the abstract, the paper had to be published between 2005-2015, and it had to be peer reviewed, 437 papers were identified. The researcher then downloaded the abstracts, titles, authors, and applicable subject (i.e. chemistry, higher education, sociology, etc.), and read them to assess which papers should be included in the final review. Papers that did not focus on higher education were excluded. After this vetting process, forty-five papers were included for review.

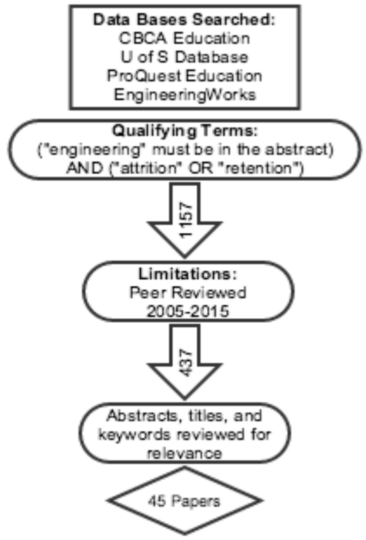


Figure 2.1: Systematic Literature Review Process.

After reading and summarizing the forty-five included papers, several themes emerged that were organized into three distinct categories or "levels": College Level Factors, Instructor Level Factors, and Student Level Factors. These category headings were inspired by Robert Marzano, who described the three levels of factors that influence the effectiveness of schools and student achievement: school level factors, teacher level factors, and student level factors (Marzano 2003), which were written with elementary and high-school education in mind. Though not intended for higher education, these levels (slightly altered) are also an appropriate way to discuss the factors that affect engineering student attrition.

2.1 **College Level Factors**

2.1.1 Institutional Climate

Institutional climate is composed of intangible factors such as how welcome students report that they feel, faculty engagement, cultural atmosphere, and the social environment. It can also include the intensity of the research environment, the existence of the "weed out" culture that exists at some engineering colleges (Kuley et al. 2015; Haag et al. 2007), and the academic achievements of students within the institution.

The importance of institutional climate on student retention and satisfaction is pronounced, especially for female and minority students (Ohland et al. 2008), which will be further discussed in Section 2.2 Student Level Factors. Though student level factors play a role in student attrition, college level factors are the underlying mechanisms that can either exacerbate or supersede student level factors. For instance, engineering schools that do not emphasize work life balance for engineering as a career will retain fewer students (Litzler & Young 2012), as will institutions that perpetuate the concept of a “weed out” culture (Suresh 2007). To retain students, it is important to take into account student demographics and societal changes that have occurred; young engineers (and students) value flexible and supportive work environments (Lozano 2015) and will look for educational experiences with this in mind.

Students who stay in engineering colleges currently are not necessarily the “cream of the crop” as weed-out culture suggests, but rather, they are often very resilient people who have a high intrinsic motivation to learn or achieve high grades, and are less affected by situational/environmental factors than their peers (Major et al. 2012). Students who drop out of engineering are generally found to be academically similar to their peers who stay in engineering (Ohland et al. 2008). The students who leave do, however, report more negative feelings towards factors such as faculty-student relationships, and report a belief that their college does not want them to succeed. When students have these perceptions, it has been found to correlate with, or predict, their eventual departure from engineering colleges (Christie 2008; Vogt 2008).

2.1.2 Workload/Curriculum

Many researchers, including Froyd and Ohland (Froyd & Ohland 2005), suggest that first-year engineering curricula are largely theoretically based and stagnant, lack context-oriented approaches, and create negative perceptions of the engineering profession for students (Kilgore et al. 2007), (Marra et al. 2012), which in turn leads to higher attrition rates within engineering colleges for millennial students who crave context and flexibility (Lozano 2015). Students value real-world examples and report that these examples enhance the quality of their education (Pomales-Garcia & Liu 2007). Without these real-world connections, students can lose interest in the profession before they even fully understand what it is that engineers do, or how diverse the profession is.

The engineering profession in Canada has always changed along with technologies and society, (Lozano 2015) and now requires interdisciplinary competencies in order to thrive (Froyd & Ohland 2005). Students want to learn what engineering is, and report that they are let down by the overloaded curriculum that lacks relevance to current engineering practice (Froyd & Ohland 2005; Ohland et al. 2008; Pomales-Garcia & Liu 2007).

There is a clear knowledge gap between some students' prior knowledge based on their background (for example, where they attended high school) (Honken & Ralston 2013; Li et al. 2009). Students that have less mathematics preparation are more likely to leave engineering, and will require more assistance than their peers in order to persist (Bamforth et al. 2005; Li et al. 2009). The varying backgrounds and academic preparation provided by students' schools and parents affect individual achievement and therefore attrition (Koenig et al. 2012). This is a predictor that is uniquely found in engineering student attrition (Walden & Foor 2008), and is in no way an indicator of students' academic capability, but rather, their individual circumstances (which are largely out of their control).

Intentionally redesigned curriculum that incorporates a more respectful atmosphere, supplemental material for underprepared groups of students, and more flexibility, was shown to improve outcomes and retention in all students (Gilmer 2007; Litzler & Young 2012; Milanovic et al. 2010; Rover 2005), but especially in the minority groups of interest to many engineering colleges in Canada. Engineering curricula combined with institutional climate is arguably the most significant predictor of student attrition, as these factors contribute to, and interact with, every other factor.

2.1.3 Mentorship

Many engineering schools have implemented mentorship programs either with industry, upper-year engineering students, or faculty; some of these efforts have been very successful in increasing retention (Budny et al. 2010; Kendricks et al. 2013; Poor & Brown 2011), while others have not (Meyers et al. 2010). However, every program documented in these studies increase student satisfaction overall. Mentorship programs seem to be particularly valuable for minority students in engineering schools (Budny et al. 2010; Kendricks et al. 2013). Minority groups in engineering (including female, LGBTQ2, Indigenous, racialized, and differently-abled students) are often lacking role models and generally have lower technical self-efficacy (strength of a student's belief in their ability to complete technical tasks and get good grades) than the dominant demographic (Li et al. 2009). Access to role models are important to student retention/attrition and success. Students are more likely to choose and continue in engineering when they themselves know an engineer (Eris et al. 2010), and are more likely to complete their degrees when they have parents that have a university degree (Honken & Ralston 2013).

Mentorship programs are one way to give these students a support system and sense that they belong there, in order to retain a larger portion of a very small proportion of the engineering student population.

2.1.4 Peer Influence and Sense of Belonging

Peer mentorship has a positive effect on students' drive to continue in engineering (Budny et al. 2010). Intuitively this makes sense; if a student has someone to look up to and guide him or her through the program, they are more likely to succeed. Also, if they have friends in the program, they are more likely to report that they "feel that [they] fit in" and belong there. Allendoerfer et al. assert that, "providing students with opportunities to belong provides the most return on investment for engagement in academic endeavors" (Allendoerfer et al. 2012).

Students who report having a lower sense of belonging tend to leave engineering colleges more often (Marra et al. 2012). A poor sense of belonging among students may indicate poor institutional climate, or that some aspect of institutional climate is affecting the student(s) feelings of belonging. If engineering students cannot foster a sense of belonging with their peers, they will find it difficult to believe that the program is worth the strenuous effort to complete (Foor et al. 2007). This intangible, but very real, sense of community and belonging is another one of the most significant factors that affect student attrition.

2.2 **Student Level Factors**

2.2.1 Academic Achievement

Given that many engineering schools in Canada accept students based on an entrance average, it is logical that higher academic achievement in high school is correlated with higher retention rates (Chimka et al. 2007; Min et al. 2011). Mendez et al. found that cumulative university GPA is most highly associated with engineering persistence or non-persistence (Mendez et al. 2008), rather than entrance average.

There are academic measures from a student's high school record that have been found to correlate with retention/attrition such as high school GPA and SAT math score (Chimka et al. 2007; French et al. 2005; Min et al. 2011). Good study and time management skills that students learned from high school have also been found to correlate with student success and retention (Bernold et al. 2007).

2.2.2 Learning Style

There is certainly an "engineering culture" that is important to foster in students (Godfrey & Parker 2010); however, under the umbrella of "engineer," there are many different personalities, learning styles, backgrounds, etc. that must be accounted for in order to increase retention and for the profession to thrive. Engineering students are a diverse group of individuals who have vastly differing backgrounds, personalities, and skills (Lozano 2015). Given the highly variable nature of engineering as a profession, students with differing personalities and learning styles all have the ability to succeed in engineering as a profession, and would add value to this diverse landscape of work (Bernold et al. 2007; Litzler & Young 2012). It is not only desirable that diversity be attained for universities, but it is recognized by employers and regulating bodies as necessary and valuable to have multiple perspectives at the table (Lozano 2015).

Though the student demographic in most engineering schools is diverse and composed of several different personalities and learning styles, many engineering courses are being taught for a very specific type of individual (Bernold et al. 2007; Watkins & Mazur 2013). Bernold et al. (2007) suggest that the types of learners and thinkers that engineering weeds out are exactly the types of learners and thinkers that industry is asking for in graduates; for example, students that are creative, innovative, and "out of the box" thinkers (Bernold et al. 2007). Engineering schools can lower attrition rates by addressing these differing learning styles and ways of thinking (Bernold et al. 2007).

2.2.3 Intrinsic Motivation and Attitude

There are some students who are so motivated to become engineers that their commitment to their education is virtually untouchable; poor faculty relationships, an over-loaded and dry curriculum, lack of community in their college, and even failure will not deter them from their goal (French et al. 2005). These students have a strong belief that engineering is the right career for them, though they may still hold negative views of engineering education or their college (Burtner 2005). These students tend to have certain types of learning styles and personality types, such as a "proactive personality" (Burtner 2005; Major et al. 2012).

Students who are intrinsically motivated are more likely to have role models (whether it is a relationship developed with instructors or previously held personal relationships) who show them what an engineering career will look like for them, and thus are more willing to persist through hardships in engineering education (or perceived hardships). These role models can act as a guiding light, showing students the end goal that helps to harden their resolve, or the role model may assure them that their struggles are "normal" and relay stories of their own experiences that help the student understand how to overcome a particular barrier. However, there are many more students who also struggle in their programs, but don't have a role model to assure them or guide them; these students may persist in their degree but are more likely to hold damaging negative views of their college and faculty. These students are more likely to report that their professors intentionally make courses more difficult than necessary to weed out students, and are more likely to leave the profession after they graduate (Suresh 2007).

2.2.4 Self-Efficacy

Lower self-efficacy is correlated with higher attrition rates, especially in female students (Meyers et al. 2010); however, students with lower self-efficacy do not necessarily differ from their peers in academic ability (Burtner 2005; Eris et al. 2010). Students' self-efficacy and self-confidence can be affected by faculty relationships, institutional climate, and teaching methodology (Vogt 2008) and are essential for student satisfaction (Heilbronner 2011). Self-efficacy is also one of the simplest factors to affect externally. If low self-confidence can be identified early on in a student's degree, interventions can be made to modify their self-perception before attrition occurs (Li et al. 2009).

2.2.5 Student Demographics

2.2.5.1 Gender

Whether female students have a higher or lower attrition rate seems to depend on the institution, as findings in this area are inconsistent. However, female students' reasons for leaving engineering colleges differ from male students (Hartman & Hartman 2006; Li et al. 2009), and they tend to leave at a different point in their educational path than male students (Min et al. 2011). Male students who leave engineering colleges tend to be less prepared than their male counterparts who continue in the program whereas female students who leave are not significantly different than their counterparts who stay in the program (Marra et al. 2012). Female students also tend to be more committed to their majors.

Female students' self-efficacy beliefs are more affected by external characteristics such as institutional climate and faculty, which contribute to student attrition. Ohland et al. (2011) suggests that female students are also more affected by curriculum practicality deficits, and that their retention is improved when engineering schools emphasize problem solving, technical writing, teamwork, entrepreneurship, and business management skills. Female students thrive when given the context of problems rather than idealized abstract problems that tend to populate the first-year engineering curriculum (Froyd & Ohland 2005).

Female students, when other variables are controlled for, are more likely to graduate than male students (Chimka et al. 2007), but are more negatively susceptible than male students to comparisons with their peers (Hutchison-Green et al. 2008), (Hartman & Hartman 2007), and more susceptible to stereotype threat (Beasley & Fischer 2012). Female students tend to have lower self-efficacy (Buse et al. 2013; Hutchison et al. 2006), which in turn contributes to female student attrition. In contrast, female students that continue in their programs have high self-efficacy and identify with the engineering persona (Buse et al. 2013), making institutional climate and self-efficacy of particular concern for the retention of female students, but important for all students regardless.

The perceived existence of problems within the engineering profession ("chilly" workplace environments) and professors who view students as "numbers, not names," etc, also contribute to student dissatisfaction and attrition for both male and female students (Hartman & Hartman 2007). Stereotypes that exist about engineers, the engineering profession, and engineering education are harming recruitment and retention efforts disproportionally for female students. However, female students that enter into engineering colleges tend to be very committed, having known that they were entering a non-traditional field (Montgomery Haemmerlie & Montgomery, Robert 2012).

2.2.5.2 Racialized Students

Caucasian students tend to have higher attrition rates than Non-Caucasian students, though Non-Caucasian students are at the highest risk for leaving later on in their degree program (Min et al. 2011). Interestingly, it has been shown that, while improving institutional climate can create gender parity, it does not affect racial disparity in engineering colleges (Ohland et al. 2011). In order to diversify their student bodies, colleges must make an investment in developing and implementing inclusive pedagogies that break down the specific barriers that exist for minority students (Ong et al. 2011; Palmer et al. 2011). Facilitating peer-to-peer connections in engineering programs and encouraging student involvement in college culture (extracurricular activities, for example) are examples of College controlled intervention strategies that may improve the retention of racialized students (Palmer et al. 2011).

2.3 **Instructor Level Factors**

2.3.1 Instructor Engagement

Faculty can have a profound effect on student outcomes, including academic performance and sense of belonging (Marra et al. 2012). If professors take the time to promote a welcoming environment and move away from verbalizing the "survival of the fittest" attitude, it will promote success in their students and reduce attrition (Christe 2013). Faculty who are perceived to be distant and unwelcoming to students, lower self-efficacy in students as well as their academic achievement overall, and make them more likely to leave their program altogether (Vogt 2008).

It is important that engineering faculty understand their role in student attrition, as it is important, and perhaps more significant than previously accepted (Christe 2013; Hong & Shull 2010; Vogt 2008). If faculty provide a welcoming environment, are actively involved in student achievement, and provide professional role models, students are more likely to report a belief that engineering is “for them” (Walden & Foor 2008).

Faculty can, and should, foster a sense of belonging in their students if a college is to reduce attrition rates and improve student satisfaction. Students report that they are more engaged in their classes when faculty are enthusiastic and willing to give time outside of class (Heller et al. 2010). Student engagement can be thought of as both a process and an outcome, with responsibility resting with both faculty members and students (Heller et al. 2010); however, challenges engaging faculty with attrition/retention results may need to be overcome (Veenstra et al. 2008) in order to promote student success and retention.

2.3.2 Professional Role Modeling

Students, particularly those in minority groups, attain better outcomes if they are able to see themselves represented in positions of power within an industry (Foor et al. 2007). Due to the historical homogeneity of engineering college cohorts, with the majority group being Caucasian males, many young students will not see themselves represented in the profession (gender disparity is often even more pronounced in faculty and in industry than in engineering colleges). This can lead students to question whether they belong in their program and profession. Having a diverse faculty complement has been shown to increase enrolment in engineering colleges, and allows students from various backgrounds to feel welcomed and understood (Trenor et al. 2008; Chubin et al. 2005) .

2.4 **Discussion of Literature Review Findings**

The identified student retention/attrition factors were grouped into three major categories, adapted from Robert Marzano's three tiers of factors that influence the effectiveness of schools and student achievement (Marzano 2003): student level factors, instructor level factors, and college level factors (Kuley et al. 2015) (Figure 3.1). The factors that can be influenced at a college level include institutional climate, curriculum, mentorship, and peer influence/sense of belonging. Instructor level factors include faculty engagement and professional role modelling. Student level factors include a student's academic achievement history, learning style, intrinsic motivation and attitude, self-efficacy, and a student's demographics (gender, Indigenous ancestry rural/urban). For the purposes of this study, these factors have been expanded to include international student status and student resilience (grit).

While the factors above have been shown to affect the retention and attrition of engineering students, it is likely that the complex interactions of these factors encourage a student to stay or leave engineering programs as they are often correlated or causally related to one another (Li et al. 2009). The impact of college level factors controlled by the institution itself (curriculum, support systems in place, college climate, etc.) are inextricably tied to student and instructor level factors.

3 Methodology

The purpose of this study was to identify any existing barriers that potentially hinder engineering students from succeeding academically. Here, success is defined as retention to the College (student persistence), though data correlations with variables measured using a survey instrument and student cumulative weighted average in their program were also explored. There were four data collection methods used in this study to answer the research question that will be discussed in this section, including: statistical analysis of historical student data, survey deployment with both quantitative and qualitative questions, interviews, and a focus group.

3.1 Theoretical Framework

In the systematic literature review outlined in Chapter 0, eleven key factors were identified as consistently impacting engineering student persistence; these factors form the basis of this research's theoretical framework. This framework was used to develop a survey instrument that addressed each factor as a construct or direct question. Figure 3.1 depicts the relationship between the eleven factors, and the level at which they act.

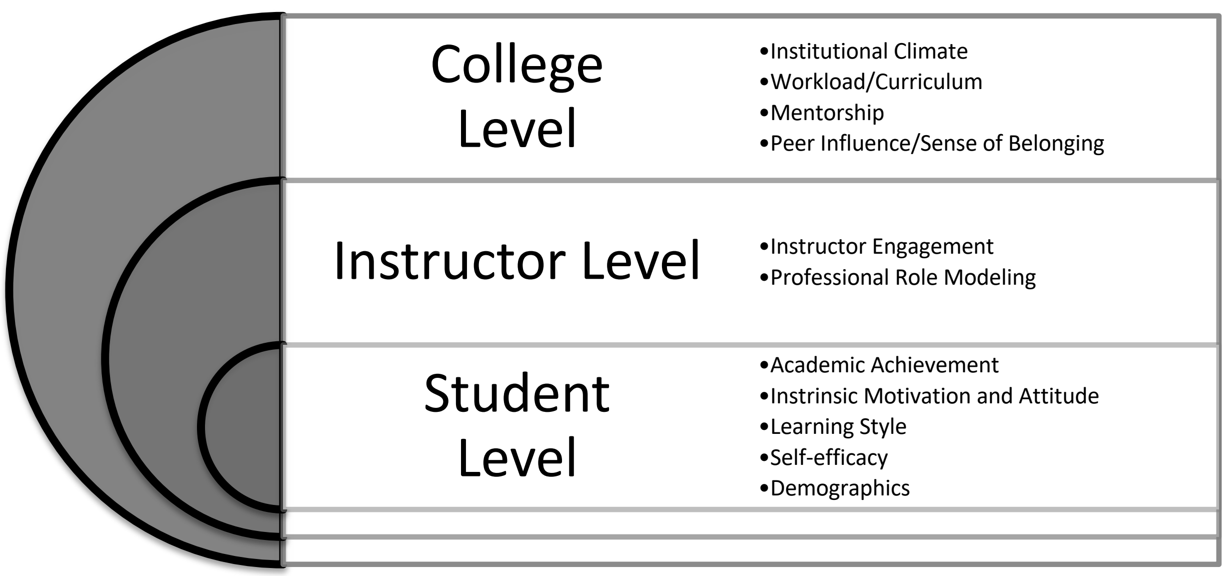


Figure 3.1: Systematic Review Framework of Factors Affecting Student Persistence

3.2 **Mixed Methodology**

Data collection generally falls into one of two types: quantitative or qualitative. Quantitative data collection and analysis methods focus on the numerical representation of participant attitudes, trends, opinions, etc, and generalizing from a sample population to a general population. It is reliant on a post-positivist worldview, which is a reductive endeavor to find a singular answer and to verify (or discredit) theory (Phillips & Burbules 2000). As a result, it does not always allow for the complexity of human experiences.

Qualitative data collection and analyses provides a deeper understanding of the views, opinions and phenomena that occur in a participant's experience. This approach is most amenable to a constructivist world view, wherein an assumption is made that participants construct their own reality based on their own historical and social perspectives, past experiences, and the culture around them (Crotty 1998). This data cannot be generalized from a sample population to a larger population without considering the context within which a participant is constructing their data contribution.

Mixed methodology research is an approach that involves the collection of both quantitative and qualitative data, the subsequent integration of this data, and the use of distinct study designs that involve philosophical assumptions and theory (Borrego et al. 2009; Leydens et al. 2004). Creswell states in his book, *Research Design: Qualitative, Quantitative, and Mixed Methods Approaches* that "The core assumption of this form of inquiry is that the integration of qualitative and quantitative data yields additional insight beyond the information provided by either the quantitative or qualitative data alone" (Creswell & Creswell 2018).

In higher education, a student's background has a significant impact on their success at university. In the search for a more holistic understanding of the barriers that exist to engineering student success, it is then a logical imperative to assess these factors through both a quantitative and qualitative lens (Leydens et al. 2004; Borrego et al. 2009). Acknowledging that there is space available in data analysis for a postmodern and constructivist worldview is congruent with a stance that Creswell calls "pragmatism" (Creswell & Creswell 2018).

Pragmatism allows a researcher to be “free to choose methods, techniques, and procedures of research that best meet their needs and purposes.” (Creswell & Creswell 2018)

This study was designed with a respect for both quantitative and qualitative contributions, centred around a pragmatic worldview of the researcher. Specifically, a concurrent triangulation, or *“convergent mixed methods design”* (Creswell & Creswell 2018) approach was chosen. A convergent mixed methods design is a single phase approach wherein the researcher collects both quantitative and qualitative data at the same time and analyses them separately (using the methods/procedures that are native to that analysis) before triangulating the outcomes (Borrego & Bernhard 2011; Creswell & Plano Clark 2011). Triangulation is a process that researchers undergo to confirm (or not) if multiple data sources converge on similar themes.

To provide a comprehensive assessment of the framework, data collection needs to address all student, instructor, and college level factors. A mixed methods study was thought to be the most effective way to reach a more holistic understanding of a problem, respecting both quantitative (QUANT) and qualitative (QUAL) data equally for offering a different facet of valuable information (Borrego et al. 2009; Leydens et al. 2004; Creswell & Plano Clark 2011). In order to appropriately collect and analyze through both lenses of academic inquiry, it is imperative that the differing goals of each are understood, and that the analysis for these inquiries are assessed based on appropriate success criteria (how to judge the validity and/or trustworthiness of the analysis). Borrego et al. outlined in their paper “Quantitative, Qualitative, and Mixed Research Methods in Engineering Education” the importance of changing the success criteria between QUANT and QUAL inquiry (Borrego et al. 2009).

3.3 Quality Criteria for Quantitative Inquiry

Engineers are often most familiar with assessing research quality based on “traditional scientific research criteria” stemming from a post-positivist worldview (Patton 2014), meaning that any connection that a researcher has to their research subjects should be minimized, as it can be seen as bias. The scientific method, in quantitative inquiry, should be followed in order to ensure that the research is objective and therefore “optimal” from a scientific perspective. In quantitative inquiry, a researcher aims to develop construct validity and reliability of a survey instrument, as well as objectivity of the inquirer defined as follows (Creswell & Creswell 2018):

- Construct validity – refers to a confidence in the survey instrument's ability to "measure the content [that it was] intended to measure";
- Reliability – refers to the "consistency or repeatability of the instrument", in particular "the degree to which sets of items on an instrument behave in the same way; and
- Objectivity – is a post-positivist objective that is "an essential aspect of competent inquiry" wherein the researcher "examine[s] methods and conclusions for bias."

3.4 **Quality Criteria for Qualitative Inquiry**

Patton states that using "traditional science" criteria to judge the quality of qualitative inquiry, by its very nature, will lead readers to conclude that qualitative inquiry is inferior (Patton 2014) and (inaccurately) of insufficient quality. As such, it is necessary to evaluate qualitative research using quality assessment criteria that are appropriate for this type of analysis. This selection of criteria depends on the purpose and epistemological and ontological positioning of the research.

3.4.1 Epistemology and Ontology

Ontology and epistemology refer to what Hays and Singh call the "nature of reality" and the "study of the process of knowing," respectively (Hays & Singh 2011). Creswell describes the combination of these terms as the "general philosophical orientation about the world and the nature of research that a researcher brings to a study," (Creswell & Creswell 2018) which often stems from a researcher's own context and background.

Given the mixed methods approach used in this study, a pragmatic worldview was employed, identified by a focus on the research problem at hand rather than subscribed methods, and the use of all approaches available to understand the problem (Rossman & Wilson 1985). Creswell states that "for the mixed methods researcher, pragmatism opens the door to multiple methods, different worldviews and different assumptions, as well as different forms of data collection and analysis," (Creswell & Creswell 2018) and highlights that "truth is what works at the time. It is not based in a quality between reality independent of the mind or within the mind. Thus, in mixed methods research, investigators use both quantitative and qualitative data because they work to provide the best understanding of a research problem" (Creswell & Creswell 2018). This statement acknowledges that understanding both what is real in our physical world, and what people feel and perceive to be real are both valid.

In the development of the survey tool, and in the interviews, a social constructivist worldview was used in analysing the resulting data, based on the belief that "multiple realities of a phenomenon exist" (Hays & Singh 2011); in this study, that is manifested as the multiple reasons why a student may leave the college, and the fact that it is likely that these reasons are contextual and differ based on that students' lived experience. For example, two students may enter the same first year cohort, attend the same classes with the same faculty, and leave with very different perceptions and experiences. Both of these student experiences are true to them, and they represent the individual nature of the student experience.

The epistemology of social constructivist research is based on the ideology that "knowledge is co-constructed between researcher and participants" and the study is considered scientific if "the data is contextually relevant and trustworthiness has been established" (Hays & Singh 2011). This acknowledges that students will conceptualize the research question differently based on their experiences, backgrounds, and what is salient to them at the time. In regard to the barriers that exist for engineering students, social constructivism acknowledges that students may be able to answer the question for their own circumstance and experience, but will not always be able to answer that same question for their peers.

3.4.2 Quality Criteria

In pragmatism, a researcher employs the norms that exist within a particular realm when using a particular method. In this case, when assessing the quality of qualitative analysis (based on social constructivist epistemology), Patton's constructivist set of criteria is most appropriate. For constructivist qualitative inquiry, good quality is akin to high levels of trustworthiness, attained by ensuring the following, as described by Patton (Patton 2014), paraphrasing Lincoln and Gruba (1985):

- Credibility - parallel to internal validity, concerns the responsibility of a researcher to speak about and reconstruct participant(s) experiences, ensuring that the collective participant voices comes through and that it is vetted by the participants themselves;
- Transferability - parallel to external validity, calls the researcher to develop detailed enough descriptions of the person/group being studied that someone else may establish the degree of similarity between your study group and another (inferring similarity of findings based on context);
- Dependability - parallel to reliability, concerns the process by which a researcher develops a study, using documented logic; and
- Confirmability - parallel to objectivity, establishes easily discernible links from a researcher's assertions to the data itself.

The strength of constructivist qualitative research is that it acknowledges that participants hold multiple perspectives and thus allows the researcher to report on the multiple experiences and interpretations of barriers that students have.

3.5 **Four Data Sets**

Table 3.1 summarizes the flow of data collection, analysis method, and the corresponding thesis methodology and results sections.

Table 3.1: Data Sets Overview

	Historical Data Collection and Analysis	**Pilot Survey**	**Full Survey**	**Interviews and Focus Group**
Timeline of Data Collection	**2005-2015 data** (Winter 2016)	Winter 2015	Fall 2016	Winter 2016
Number of Students Surveyed	n/a	525 (only first-year students)	1700 (all undergraduate students)	n/a
Number of Respondents	N = 4680	n = 84	n = 370	n = 10
Methodology Section	0	3.5.2	3.5.3	3.5.4

Results Section	4.1	4.2	4.3 and 4.4	4.5
Data Type	QUANT	QUANT+QUAL	QUANT+QUAL	QUAL
Quality Criteria	Section 3.3	Sections 3.3 + 3.4	Sections 3.3 + 3.4	Section 3.4

3.5.1 Historical Data

An archival database was created for use in this study, which included ten years of student data. The data included all students who had started an engineering program between 2005-2015 (N = 4680) and was obtained through the College. A snapshot of this data was then taken using the RibbonTool™ (University of Saskatchewan 2018) to identify trends in a five-year graduation rate between various subgroups of students.

Archival data from the College was used in tandem with survey data to identify trends and correlations with student perceptions and retention, as well as demographic factors and academic history. This data was coded into the following categories for analysis: students who have convocated, students who left the College and did not return, and students who could not be assessed with certainty. For example, some students leave for a year and then come back, or go on internship for 8, 12 or, 16 months; these students were not included in the analysis.

3.5.2 Pilot Survey

To kick-off the project, a pilot survey was sent out to students (n = 380) with explicit questions, such as “why do you think that students leave the College.” Questions were generated by the researcher and Graduate Advisory Committee, without the use of an overarching framework. This experience led to the creation of the rigorous framework that was used in development of the full survey.

3.5.3 Full Survey

The full survey instrument was developed to characterize the student population of the College, using existing scales for self-efficacy (Pintrich et al. 1991), grit (resilience) (Duckworth & Quinn 2009; Duckworth et al. 2007), and academic motivation (Vallerand et al. 1992). These established scales have been previously validated and tested for reliability. To measure the remaining factors, unique constructs were created and assessed using face validity and expert validity procedures. These constructs were then tested for reliability; the analysis results for this are reported in Table 4.3.

Surveys were sent by email to all current students (n ~ 1700) by the Engineering Student Centre. Students' emails were not provided to the researcher. The survey was created online using the program FluidSurvey, where student answers were provided and maintained as confidential. Data analysis was completed in Excel, SPSS, and within FluidSurvey.

3.5.4 Interviews and Focus Group

As part of this concurrent mixed methods study, qualitative data was an equally important data source used to assess qualitative factors and challenge assumptions that may have been made with quantitative data alone, as well as to see if findings converged or overlapped.

Email invitations to participate in an interview or focus group were sent to all students who were in the top 10% and bottom 10% of their first year cohort. Five students from the bottom 10% and five students from the top 10% answered this request. Each student was then asked whether an interview or focus group would be their preference. The five students from the top of their cohort (who all happened to be in the top 5%) indicated that a focus group would be their preference. The five students from the bottom of their cohort each answered that an interview would be their preference. Thus, one focus group (total 5 people) and five one-on-one interviews were conducted following a semi-structured interview guide. The interviews were recorded on an iPad at discrete locations outside of their "home" building (the engineering building) and were then transferred onto secure university servers (and were deleted off of the recording device). The discussions were transcribed, and the electronic recording file was deleted off of the server. The raw data was analysed using NVIVO software by applying an inductive coding procedure, wherein predefined themes were not used, and identifying themes as they emerged with greater frequency in the data (Creswell 2005). The students' names were kept confidential, and their comments were anonymized.

This methodology was used to identify discrete ideas that emerge from participant transcripts and subsequently to identify themes that were supported by the text. In the case of this study, themes were identified as students answered the questions below.

3.5.4.1 Interviews

Semi-structured interviews were conducted, in order to give participants freedom to talk about important matters and emergent factors, while maintaining enough structure to guide the conversation towards retention and student experience within the College.

The questions used in these semi-structured interviews were as follows:

1. Can you tell me about your first semester experience?
2. Are you planning on continuing in engineering? Why or why not?
3. What do you feel are barriers to your success in engineering?
4. What things are done well in the first-year program?
5. What type of assistance could the College provide to help first-year students?
6. Why do you feel that students leave the College of Engineering?

These questions were created by the researcher and approved by the Graduate Advisory Committee. The same questions were used in the focus group, though the language was adjusted to include multiple participants (ex: "Can you all please tell me about your first-year experiences"). Students were contacted to request their participation in a voluntary interview by the Engineering Student Centre (ESC) if they had been below 50% in their first semester of engineering and were likely to drop out (from the perspective of the ESC).

Interviews were chosen for students who were struggling in their program, as it has been found that students are more open to sharing in a one-on-one setting when students may feel embarrassed about their current situation, and confidentiality was of utmost importance (Gubrium et al. 2012). Confidentiality is strengthened in this setting, as the identity of the interviewee is known only to the interviewer.

3.5.4.2 Focus Group

Focus group questions followed the same structure as above, only these students were chosen from the top 5% of their first-year cohort. The goal in interviewing successful students was to see if they reported more positive experiences in the College than their struggling counterparts. A focus group was employed to allow the interplay of students' opinions to foster deeper understanding of their experiences (Leydens et al. 2004). Confidentiality and comfort level were less of a concern for these students as participants indicated when they agreed to participant in a focus group.

3.6 **Impact of Insider Research Status on Methodology**

The insider nature of this research, of course, invites criticism that bias will emerge in the analysis and interpretation of data. While there are many benefits to being an "insider," there unavoidable trade-offs such as pre-conceived notions and opinions of the researcher. Several strategies were employed to mitigate the effects of any potential bias: I aimed to internally validate findings by using several data sources and methodologies, I distanced myself from data collection as much as possible by distributing the survey through the Engineering Student Centre, and engaged in reflexive practice to ensure that I was aware of my own opinions and thoughts on any given theme (used as a lens through which to check results).

Because the research topic is one that I have an interest in, particularly in enhancing minority participation in the field of engineering, I had to consistently reflect on the assertions that I was making to ensure that they were supported by student data, or adopt a position of "critical suspicion" (Lawson 1985). This involved thinking through any conclusions and results, tying them to student data and statements to ensure that these assertions were not made without evidence that stemmed directly from student responses

3.7 **Variable Overview**

The following Table 3.2, is a complete list of variables used alongside their variable type. Variables are denoted as one of the following variable types, as defined by Laerd Statistics (Laerd Statistics 2018):

- Ordinal - this data is categorical, and has an ordered scale attached to it. (i.e. students chose whether they agreed with a statement on a scale from 1-5);
- Nominal - this data is categorical, but not ordered (i.e. students are male or female, but neither category is "better" than the other);
- Dichotomous - this data is a specific type of nominal data type, with only two, mutually exclusive answers possible (i.e. a student left the college or did not); and
- Continuous - is data that has infinite possible values, though it can be constrained between two numbers (i.e. a student's entrance average can range between 0%-100%).

Table 3.2: Complete List of Study Variables

Historical Database

Variable	**Data Type**
Attrition	Dichotomous
Direct Entry vs. Transfer or Mature Student	Nominal
Entrance Average	Continuous
Location Listed on Student Application	Nominal
Current Registration Status	Dichotomous
Cumulative Degree Average	Continuous
Discipline	Nominal
Gender	Dichotomous
International/Domestic	Dichotomous
Self-identified Indigenous Status	Dichotomous
High School English Grade	Continuous
High School Chemistry Grade	Continuous
High School Physics Grade	Continuous
High School Math Grade	Continuous

Historical Database

Variable	Data Type
Age of Student	Continuous
High School Location	Nominal
Convocation Status	Dichotomous
Entrance Average Courses (x5)	Nominal
200509 Average	Continuous
200601 Average	Continuous
200609 Average	Continuous
200701 Average	Continuous
200709 Average	Continuous
200801 Average	Continuous
200809 Average	Continuous
200901 Average	Continuous
200909 Average	Continuous
201001 Average	Continuous
201009 Average	Continuous
201101 Average	Continuous
201109 Average	Continuous
201201 Average	Continuous
201209 Average	Continuous
201301 Average	Continuous
201309 Average	Continuous
201401 Average	Continuous
201409 Average	Continuous
201501 Average	Continuous

Full Survey Data

Variable	Data Type
Attrition	Dichotomous
Faculty Engagement Construct	Ordinal/Continuous

Full Survey Data

Variable	Data Type
Year in Program	Ordinal
Type of Admission	Nominal
Aboriginal Ancestry or Not	Dichotomous
Role Model Construct	Ordinal
Faculty Mentorship Construct	Ordinal
Gender	Dichotomous
High School Attended Prior to Entering the College	Nominal
Discipline	Nominal
International Student Identifier	Dichotomous
Cumulative Degree Average	Continuous
Entrance Average	Continuous
High School English Grade	Continuous
High School Chemistry Grade	Continuous
High School Physics Grade	Continuous
High School Math Grade	Continuous
Institutional Climate Construct	Ordinal/Continuous
Curriculum Construct	Ordinal/Continuous
Resilience Score	Ordinal/Continuous
Self Efficacy Score	Ordinal/Continuous
Self efficacy - Dichotomous Variable	Nominal
Sense of Belonging Construct	Ordinal/Continuous
AMS-28 Motivational Construct – To Know	Ordinal/Continuous
AMS-28 Motivational Construct – Accomplishment	Ordinal/Continuous
AMS-28 Motivational Construct – Stimulation	Ordinal/Continuous
AMS-28 Motivational Construct – Identified	Ordinal/Continuous
AMS-28 Motivational Construct – Introjected	Ordinal/Continuous
AMS-28 Motivational Construct – External	Ordinal/Continuous
AMS-28 Motivational Construct – Amotivation	Continuous
Grade below which the students would be deeply disappointed	Continuous

Full Survey Data

Variable	Data Type
Expected or actual grade received (first-years vs upper-years)	Continuous
Disappointment Threshold Delta	Continuous
Institutional Climate Construct	Ordinal
Curriculum Construct	Ordinal
Faculty Engagement Construct	Ordinal
Professional Role Modeling Construct	Ordinal
Question: My instructors expect that we know more about a subject than we do coming into a class	Ordinal
Question: I feel that I have learned enough in my previous classes in order to get by in my current classes	Ordinal
Question: Peer Influence/Sense of Belonging	Ordinal
Question: I can see myself working as an engineer	Ordinal
Question: I feel as though I "fit in" in engineering	Ordinal
Question: I feel at home at the University of Saskatchewan	Ordinal
Question: I am similar to most other engineering students	Ordinal
Question: I have good friends who are also in engineering	Ordinal
Question: When I feel stressed out or overwhelmed by my classes, I know that other students are feeling the same	Ordinal
Question: I feel less stressed out than my peers	Ordinal

Qualitative Survey Questions

Variable	Data Type
What could The College do/change to make first year more successful for engineering students?	Open ended
Are there any specific things that you can think of that act/acted as barriers to your success in engineering?	Open ended
Is there anything in your engineering degree so far that you feel is done well and helps students succeed?	Open ended
Is there anything else that you would like us to know about your first year experience?	Open ended

4 Results/Analysis

This results chapter is organized by the four data collection method data sets within this concurrent triangulation mixed methods study (Creswell & Plano Clark 2011). An analysis of historical data is reported, which was intended to decipher if any combination of high school courses could predict attrition and/or academic achievement. Additionally, the proportional outcomes after five years of various students are compared (international vs. domestic, for example) using a subgroup of student population who began their program in 2012 were compiled and included below to highlight the potential differences in these sub-groups. This is followed by the descriptive statistical analysis of the pilot survey, which provided insight into the type of study that should be conducted to identify the barriers that exist to student success. The pilot survey was integral in developing a foundation upon which to build the full survey that followed.

The full survey was built around a framework developed based on the literature review conducted for this thesis (Kuley et al. 2015). Both quantitative and qualitative results from the full survey are reported, as they both provided insight into students' perceptions and the diverse experiences of this student body. This is followed by a thematic analysis of several interviews that were conducted with students who were struggling in their program, as well as one focus group discussion held with students who were at the top of their class.

4.1 Historical Data

Data were obtained for students who were in a U o f S engineering program between 2005-2015 (N = 4680), the most recent ten years as of the data of data collection. This was done in order to identify if any high school course grades predicted whether or not a student would persist in their program, though this did not account for changes in curriculum that may have occurred throughout the years. A snapshot of this data was then taken to identify trends in a five-year graduation rate; although engineering programs are typically four years, fewer than 22% of students graduate in four years from any given cohort (start year).

4.1.1 Ten Year Historical Data

The use of ten years of historical student data was essential in answering the question, *do high school grades predict attrition and/or academic success*?

High academic achievement in high school has been found to correlate with higher retention rates in various studies (Min et al. 2011; Mendez et al. 2008). Further studies have been conducted that found that specific classes or test scores (from high school) can predict whether or not a student stays or leaves an engineering program (Chimka et al. 2007; French et al. 2005). In order to assess whether these findings held true for the University of Saskatchewan, a multiple linear regression was attempted, wherein the dependent variable "y" can be predicted by independent variables x_1, x_2, x_n when multiplied by coefficient factors, β_0, β_1, β_2, β_n:

$$y = \beta 0 + \beta 1x1 + \beta 2x2 + \cdots \beta nxn$$

Many independent variables were tested in this equation, aiming to predict the dependent variables: binary attrition/retention, and the cumulative average of a student. However, due to a high degree of multicollinearity (when the independent variables were not independent) in this data, a simpler version of regression was necessary. In this case, the independent variables of a student's entrance average, English class average, math class average, and physics class average all correlate to one another i.e. if a student has a high grade in physics, they are likely to have a high grade in English as found in this data set.

Several singular linear regression analyses were conducted in order to discern which courses had the most impact on a student's academic performance, and then several binary logistic regressions were conducted on the dependent attrition variable to predict a student's likelihood of persisting in the College given various grade twelve high school course grades (as reported on their official transcript from high school). Analysis was done to determine the effects that entrance average, high school english grade, high school math grade, and high school physics grade have on cumulative degree average as a dependent variable using linear regressions. Additionally, separate binary logistic regressions were completed with attrition as the dichotomous dependent variable, using the same independent variables. This allowed an understanding of the effect of each variable individually given the high degree of multicollinearity between the high school subjects. These analyses were completed using historical data from the College for all undergraduate students between 2005 and 2015. In all cases, the regression was significant at Confidence Interval (C.I.) = 95%. The proportion of Variance, R^2, provides insight into the percentage of variability in a dependent variable that can be explained by an independent variable. For example, a students' high school math grade predicts approximately 30% of the variability in their cumulative degree average, and approximately 16% of the variability in a student leaving the College.

Table 4.1: Individual Regression Analysis For High School Course Grades

Variance Explained for New Direct Entry Students in Attrition and Cumulative Degree Average (N = 4680)

Independent Variable	Hosmer Lemeshow Test (Significance value, α)	Attrition Variable, proportion of variance, (Nagelkerke R^2)	Cumulative Degree Average Variable, proportion of variance, (R^2)
Entrance Average	0.007*	11.7%	24.3%
High School English Grade	0.663	6.9%	14.7%
High School Math Grade	0.113	16.1%	29.9%
High School Physics Grade	0.075	9.7%	22.3%

*significance at C.I. = 95% indicates poor goodness of fit for a logistic regression model, suggesting that either the correlation is dubious or that perhaps a more complicated model would be required to accurately describe the relationship between these two variables.

In the table above, high school math is the strongest predictor of student outcomes. The most notable finding from this analysis, however, is that none of the indicators predict student outcomes well. In particular, the entrance average that is used to determine a student's admission to the College predicts only 11.7% and 24.3% of variability in a student leaving the College and their cumulative average, respectively. Although this number is used to admit students, it is a poor predictor of their performance, indicating that other factors are playing a larger role in student retention and success than the factors that we currently use to admit students to their programs.

4.1.2 Proportional 5-Year Outcomes for Students of Different Groups from Snapshot Cohort

Each of these comparisons was created using a five-year graduation rate, meaning that the data came from students who began their studies in September of 2012 (N = 468), and tracks them through to September of 2017. A data visualization tool was used to track and compare retention data between students of different genders, international student status, age, high school average, and self-reported indigenous heritage (University of Saskatchewan 2018). These data sets and their corresponding descriptive analyses are included below, indicating the percentage of students who were awarded an engineering degree, were still enrolled, moved to another U of S program, or who left the University of Saskatchewan altogether.

4.1.2.1 High School Average

Figure 4.1 indicates that students who have higher overall averages in their grade twelve year of high-school tend to leave the university less often than their peers.

At first, it may seem as though students who have a high school average of below 75% are not following the trend; however, these students would not be eligible for entry using their high school grades and likely have upgraded or received another degree, which would not be captured in our data. In any case, no strong inferences can be made about that sub-group. Note that “nan” stands for “not a number,” which means that high school average data was not available for those students.

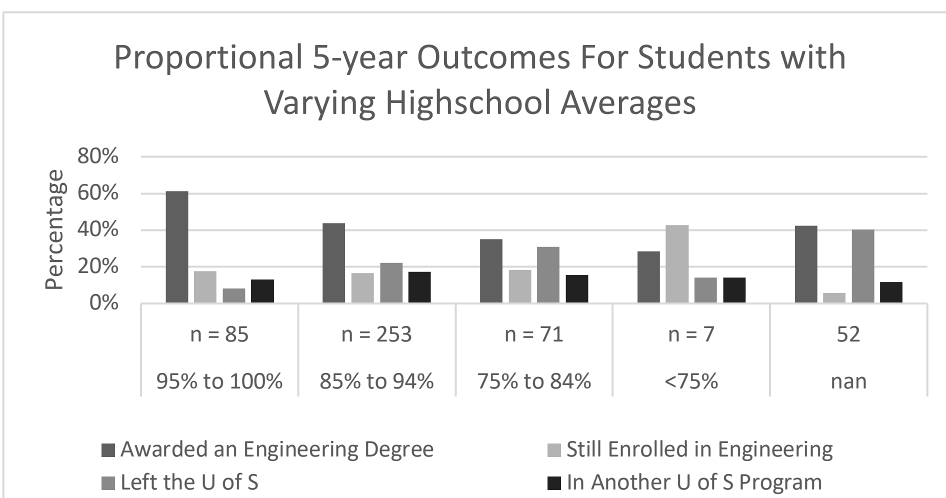


Figure 4.1: Proportional 5-year Outcomes for Varying High School Grade 12 Average

4.1.2.2 *Gender*

Though there is a belief that female students leave engineering colleges more often than their male peers (Min et al. 2011), the data shows that this is not the case at the U of S (see Figure 4.2 and Appendix B – Gender Based Analysis of Pilot Survey Data). Not only do female students proportionally tend to graduate with engineering degrees slightly more often after five years compared to male students, male students are also nearly twice as likely to leave the university without any degree at all. The data does not indicate what happens to these students after they leave, particularly if they transfer to another institution.

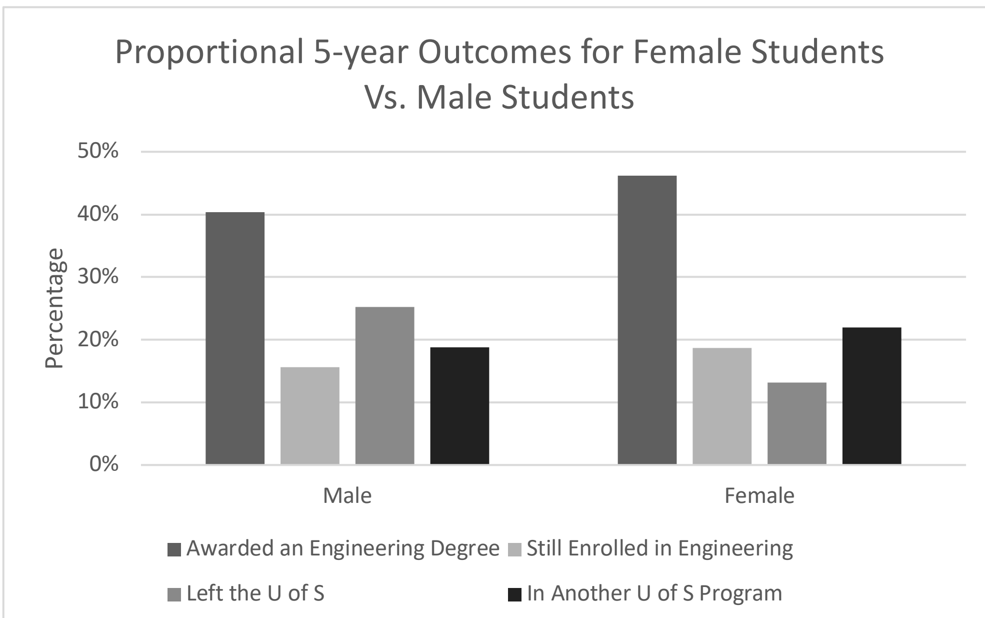


Figure 4.2: Proportional 5-year Outcomes for Students of Different Genders

4.1.2.3 *Indigenous Students vs. Non-Indigenous*

Given the low cohort numbers of Indigenous students, a clear trend cannot be ascertained in the data.

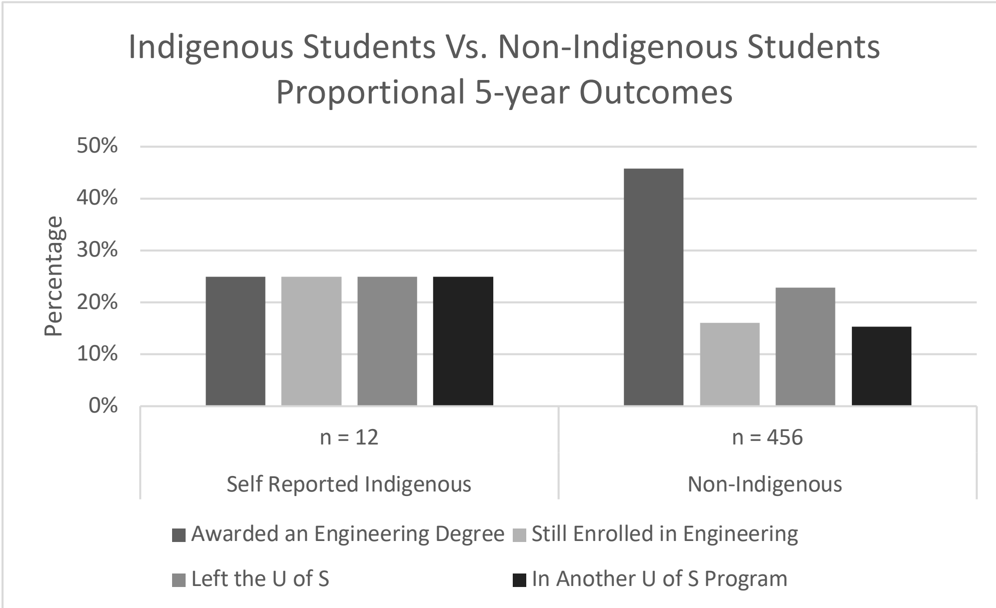


Figure 4.3: Proportional 5-year Outcomes for Indigenous vs. Non-Indigenous Students

4.1.2.4 Domestic vs. International

International students are shown to leave the University of Saskatchewan more often within five years compared to domestic students.

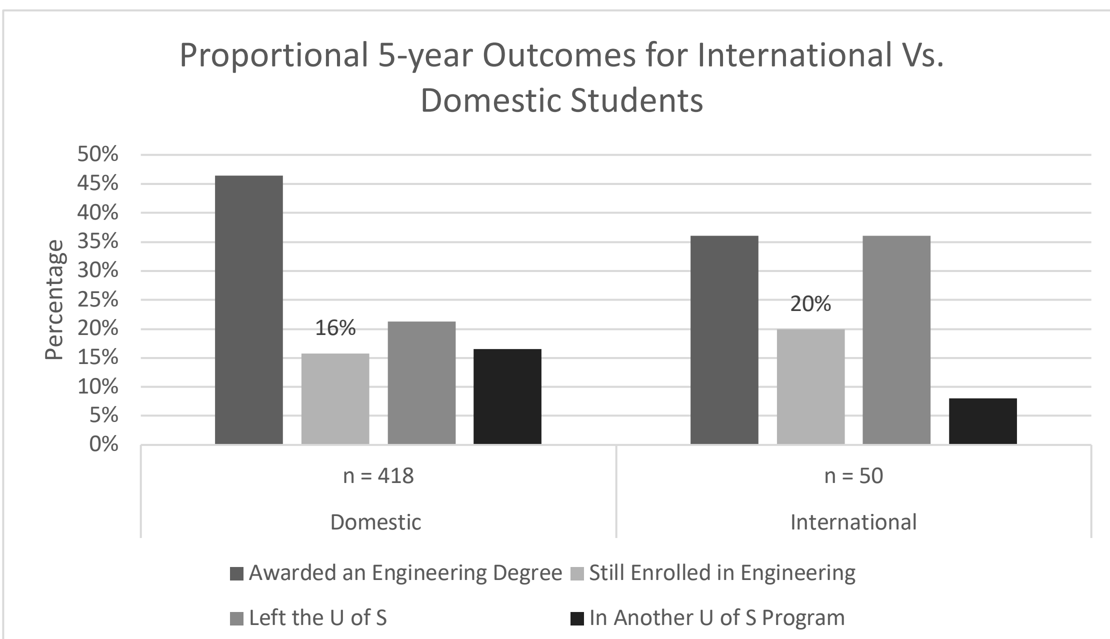


Figure 4.4: Proportional 5-year Outcomes for Domestic vs. International Students

4.1.2.5 Urban vs. Rural Students

The data clearly shows that urban students from Saskatchewan have the best outcomes in the College's programs, with rural students from outside of the province proportionally leaving most often (though the numbers are very low). Twenty-eight percent of rural students from Saskatchewan left the university within five years compared to 16% of urban students from Saskatchewan.

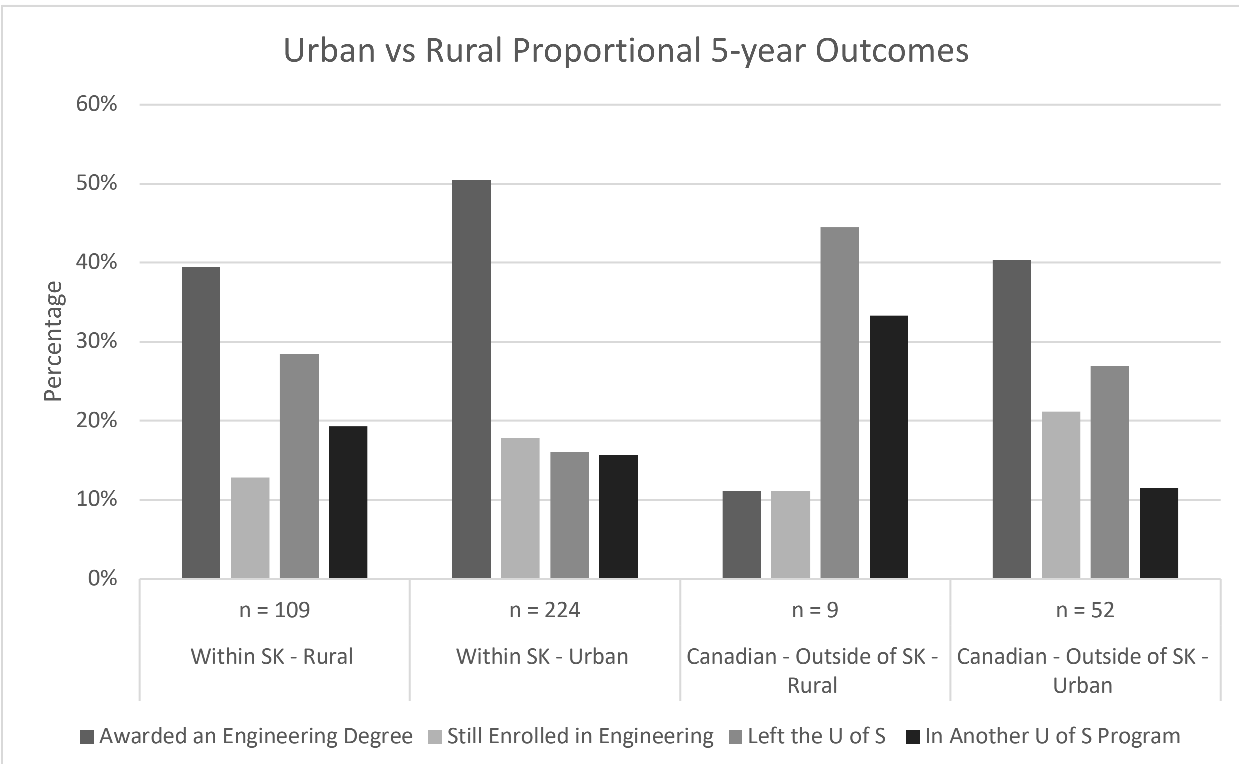


Figure 4.5: Proportional 5-year Outcomes for Rural vs. Urban Students

4.1.2.6 Age

The data below shows a weak trend wherein students who are above the age of 20 years old at the start of their degree receive degrees within five years as often as younger students, but tend to leave the U of S altogether (almost twice as often) if they do not receive an engineering degree. An average of 31% of students over the age of 20 years old leave the university, whereas only 20% of students who are 18-20 years old tend to leave the university altogether after starting an engineering degree. Note that there were no students in this cohort aged 30+.

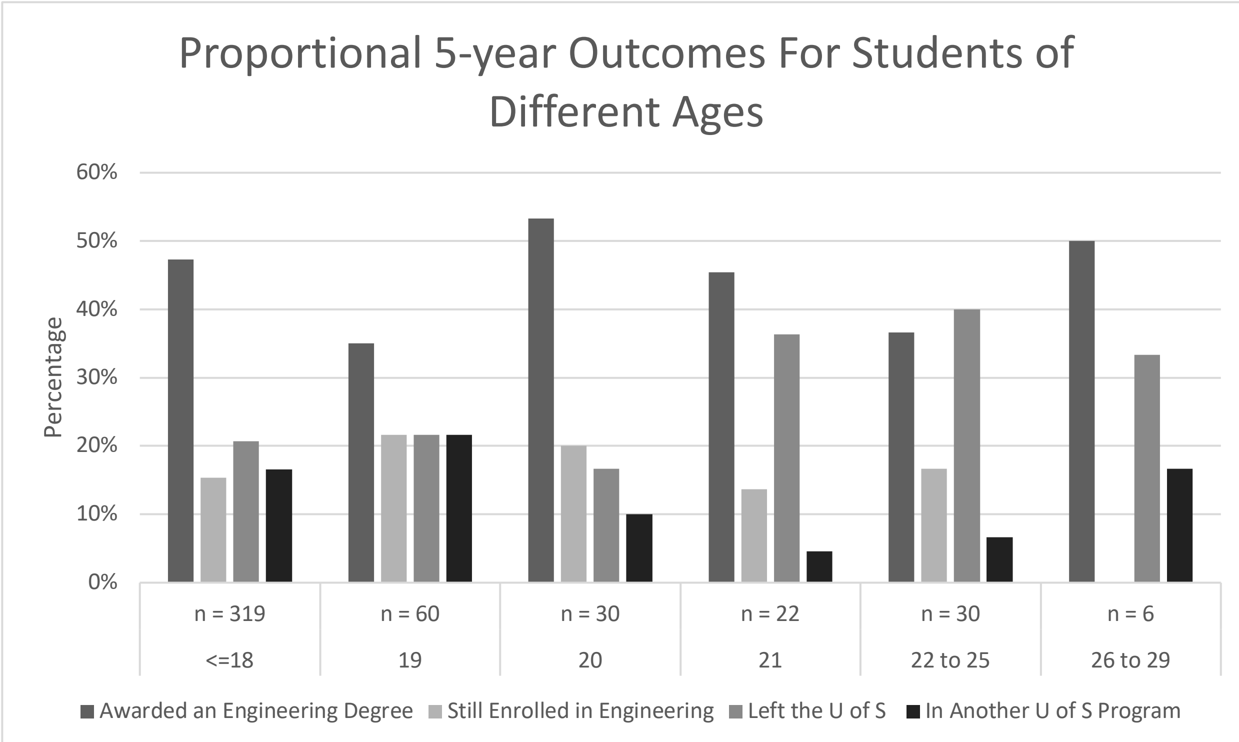


Figure 4.6: Proportional 5-year Outcomes for Students of Different Ages

4.2 **Pilot Survey Analysis**

This survey was deployed to 525 first-year students by email in January of 2015. The initial survey results included a participant number of 84 (a 16% response rate among first-year students), with subgroup numbers being too low to conduct inferential statistical analyses representing the student population. A full descriptive analysis was completed and is included in Appendix C; highlights from the pilot survey are discussed below.

When students were asked “what was the main reason you decided to enter into the College of Engineering?” their responses were typical of engineering students in general (Engineers Canada 2017), in that they said mostly “I was good at math and science.”

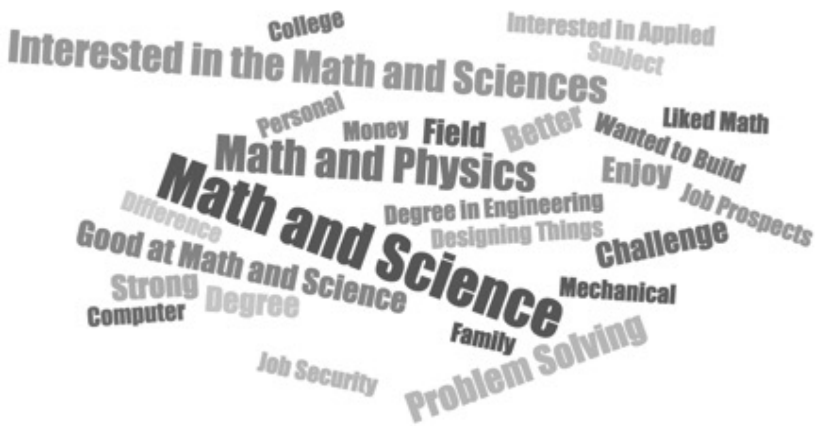


Figure 4.7: Why Did Students Enter Engineering Word Cloud

Full analyses of this data, to define differences in student answers based on international student status, self-declared indigenous student status, and gender were also conducted; however, no inferences were possible given the small number of participants for this survey and the even smaller break-out groups.

Eleven out of seventy-five respondents indicated in the pilot survey that they were considering leaving the College. When asked what contributed to their uncertainty, they indicated the following in Table 4.2, which closely aligns with barriers to engineering student success identified by Engineering Canada (Engineers Canada 2017):

Table 4.2: Student Answers to the Question "Why Are You Considering Leaving the College"

Reason Stated	Yes	No	Uncertain	N/A
Heavy Work Load	55%	27%	18%	0%
Professor/Teaching Quality	55%	18%	27%	0%
No Sense of Community	46%	46%	0%	9%
Poor Grades	46%	46%	9%	0%
Inadequate Tutorials/Help Sessions	46%	45%	0%	9%
Financial Difficulties	36%	46%	9%	9%
"Culture Shock" (Living on Your Own in a New City)	36%	36%	9%	18%
Facilities (Not Enough Space, Not a Comfortable Learning Environment)	36%	55%	9%	0%
Engineering Wasn't What I Thought it Was	36%	64%	0%	0%
Lacking Student Centre Support	27%	55%	9%	9%
Procrastination/Poor Study Habits	27%	64%	9%	0%
Lack of Time Management Skills	27%	64%	0%	9%
Insufficient Lab (Hands On) Work	18%	64%	18%	0%
Inadequate High School Education	0%	91%	0%	9%

Without the ability to conduct inferential statistics, the pilot survey gave us insight into how to adjust our participant recruitment strategies and served to develop the second iteration in the full survey, which is described in the following section.

4.3 **Quantitative Analysis of Full Survey**

This survey was deployed to all undergraduate engineering (N = ~1700) students in December of 2015. The response rate n = 365, represented approximately 21% of the total student body, including 40% of the first-year cohort. The purpose of this survey was to characterize our students and track them through the year to see if any had left, and identify patterns or trends that emerged.

For the purposes of this thesis, wherever possible, the construct scores were standardized for easy comparison. This was done by categorizing construct scores - the average score of all items within the construct - into thirds (0 - 33rd percentile, 34th - 66th percentile, and 67th - 100th percentile), which were labeled "poor," "fair," and "good." For example, each student was allocated a self-efficacy score between 0-5 based on their answers to questions within the self-efficacy construct, a scale previously developed by Pintrich (Pintrich et al. 1991). If the student answers scored between 0 and 1.67, they were placed in the "poor self-efficacy" category, similarly, scores between 1.68 and 3.33 were considered "fair", and 3.34 to 5.00 was labeled as "good."

4.3.1 Created Construct Reliability

Several of the constructs measured in the full survey instrument were explored using previously developed and validated scales, including: self-efficacy, academic motivation, and resilience. The reliability analysis (Cronbach's alpha) is included below for reference. For the remaining factors, constructs were developed and tested for reliability. The results of the completed reliability analyses are shown in Table 4.3:

Table 4.3: Reliability Analysis of Each Construct in the Survey

Construct/Factor	**Reliability Analysis (Cronbach's Alpha)**
Academic Achievement	This data was addressed using historical databases
Institutional Climate	0.73
Curriculum	0.74
Mentorship	Question was asked directly
Peer Influence/Sense of Belonging	0.77
Faculty Engagement	0.74
Professional Role Modeling	Question was asked directly
Motivational Style	0.83-0.86
Resilience/Grit	0.75
Self-efficacy	0.93

A Cronbach alpha value above 0.7 is typically suggested as a cut-off (Nunnally 1978) number for when a construct is reliable enough for statistical use. The constructs in the survey met the criteria and were thus used in statistical analysis as is, rather than breaking them into their individual survey items.

4.3.2 Full Survey Demographics

Cross-tabulation was completed to see if any of the above factors differed within the demographic pairs shown in Table 4.4 (for example males vs. females). The overview of the respondent pool is as follows:

Table 4.4: Respondent Pool Descriptive Data

Percentage of Student Respondents (n = 365)

Male	73.7%	Female	26.3%
Domestic	93.4%	International	6.6%
Non-Indigenous	96.7%	Indigenous	2.3%
First-year student/undeclared	40%	Upper-year student	60%

The respondents represented each engineering discipline offered at the University of Saskatchewan, as shown in Figure 4.8:

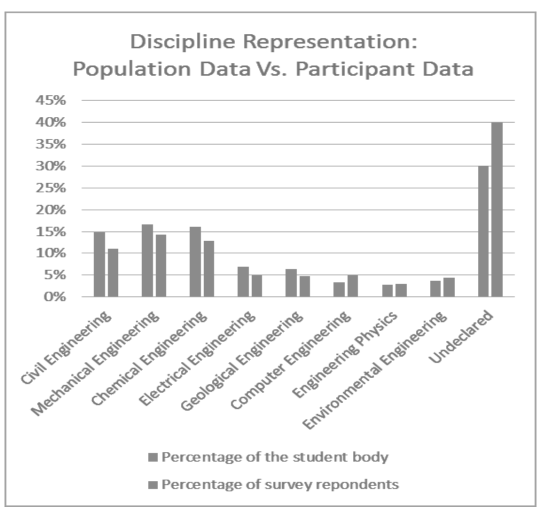


Figure 4.8: Discipline Representation of Respondent Pool.

The participants included 27% female and 73% male students (compared to 19% female students in the undergraduate population), 3% self-declared aboriginal students (compared to 3.5% in the total undergraduate population), and 7% international students (compared to 13.5% in the total undergraduate population).

4.3.3 Descriptive Statistics

A full descriptive analysis report of the full survey can be found in *Appendix G – Descriptive Analysis of Full Survey*. The following are distilled highlights from each construct.

4.3.3.1 Workload

To characterize student perceptions about curriculum, participants were questioned about their workload by asking about their level of agreement with five defined statements (survey items) including, "I have no time for anything other than studying," and "I find it easy to manage my classes along with my personal life," the latter of which was reverse coded before analysis. A factor analysis was conducted between these survey items to see if these statements could be combined into a "curriculum" factor that aimed to see how students perceived their workload. The reliability analysis of this construct was significant with an Cronbach alpha of 0.74, meeting the generally accepted guideline of being above 0.7 (Nunnally 1978), and thus it was used as a construct in this analysis (Figure 4.9).

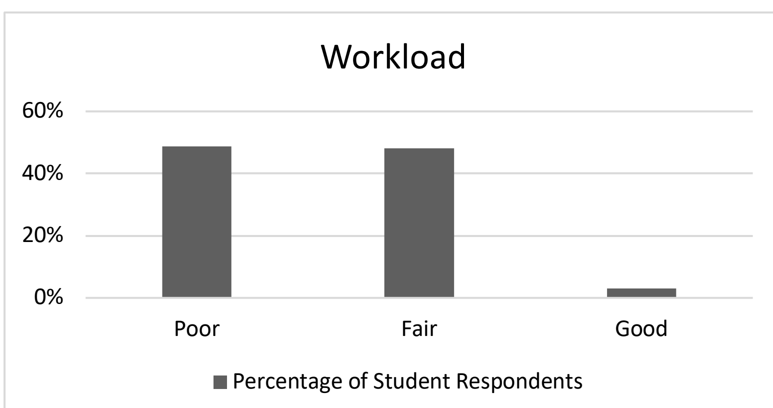


Figure 4.9: Curriculum Construct Results

Students were also asked if their instructors expected them to know more of the material required for a class than they had learned in high school. Many students reported that they did not have enough background knowledge coming into their classes. The following chart shows the percentage breakdown of student respondents who answered the question “my instructors expect that we know more about a subject than we do coming into a class” (the answers available to students were “not at all true,” “sometimes true”, “true about half the time”, “usually true” and “very true”):

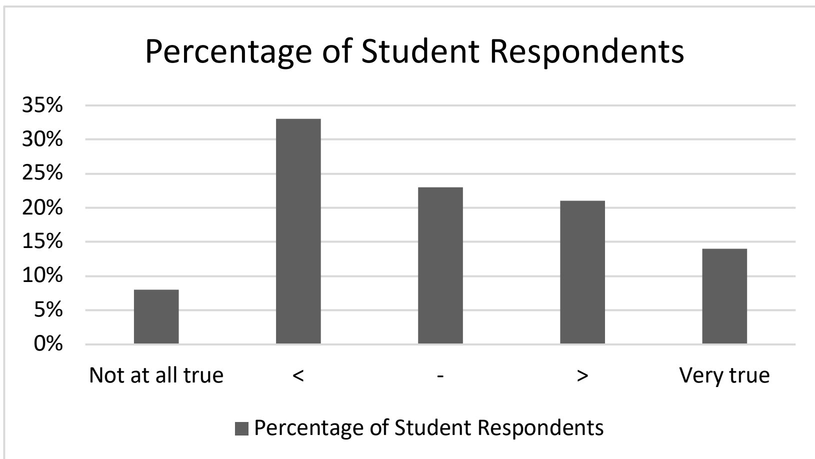


Figure 4.10: Student Responses to the Question “My instructors expect that we know more about a subject than we do coming into a class?"

4.3.3.2 *Institutional Climate*

Institutional climate is an abstract, but very important construct, comprised of many intangible factors such as how welcome the students report themselves to be, what the cultural atmosphere is in a college, as well as its social environment (Kuley et al. 2015). As indicated in the following graph, the engineering student respondents reported that the College is very welcoming. It has been shown that students who leave due to institutional climate are not academically different than their peers (Ohland et al. 2008).

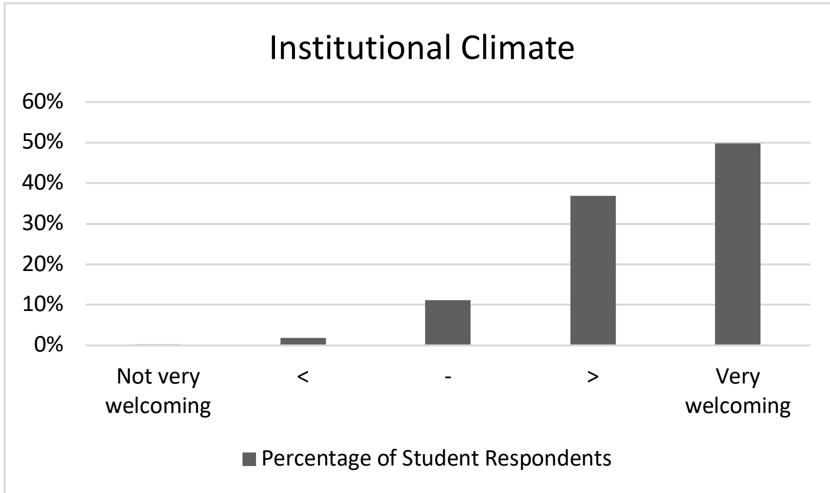


Figure 4.11: Institutional Climate Construct Results

4.3.3.3 *Mentorship and Professional Role Models*

When participants were asked if they have existing mentors in their life who are engineers, they responded as indicated in Figure 4.12. Given the knowledge that professional role models serve as a “guiding light” that helps students to persist, it would be ideal for all students to indicate that they have those professional role models. The data below shows that many students do not indicate that they have a role model to serve this purpose:

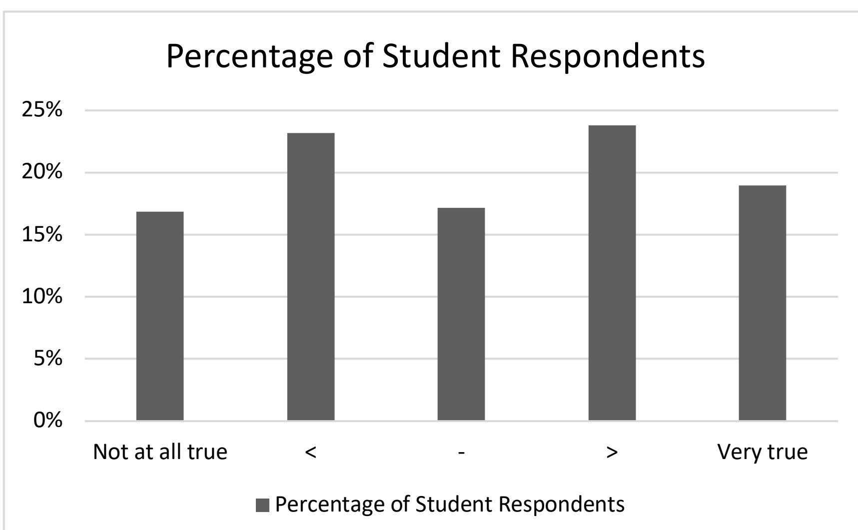


Figure 4.12: Student Responses to the Question, "Do you have existing mentors in your life who are engineers?"

When asked if they consider their professors as a role model for their engineering career, the responses are as summarized in Figure 4.13. Again, students are split on whether or not they see their instructors as role models:

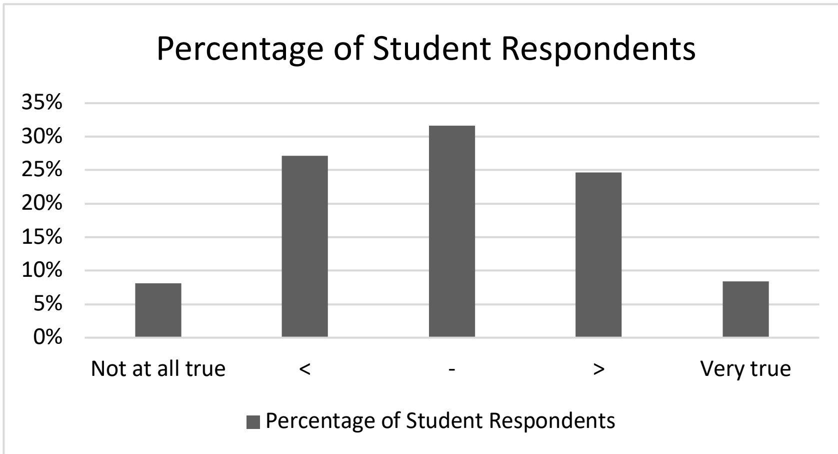


Figure 4.13: Student Responses to the Question, "Do you consider your professors to be role models for your career?"

4.3.3.4 *Resilience*

Although resilience did not come up prominently in the literature review, it was decided for this study to see if a student's level of resilience influenced their choice to stay in college. Duckworth's Grit Scale (Duckworth & Quinn 2009) was used to assess this factor/construct. Current University of Saskatchewan engineering students were found to have "high to very high" levels of grit (resilience, see Figure 4.14), indicating that this cohort is more likely to persist in the College despite barriers that may arise.

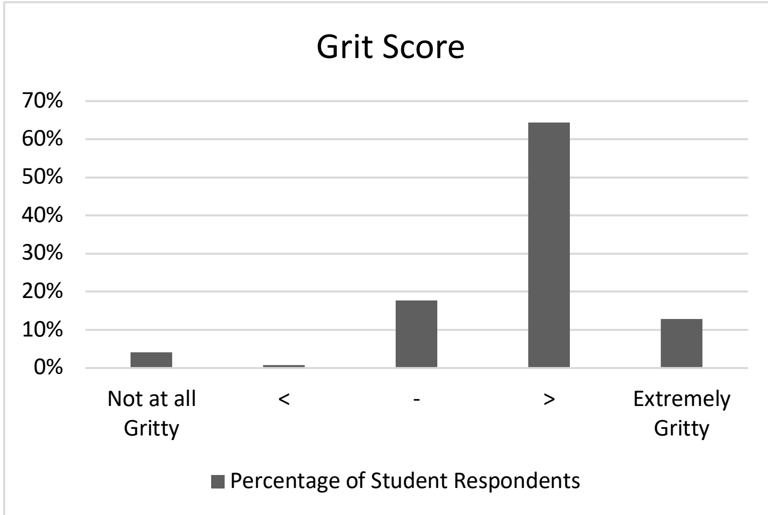


Figure 4.14: Resiliency Construct Results

4.3.3.5 Peer Influence and Sense of Belonging

A student’s sense of belonging in their academic setting has profound effects on their experience at an institution and in a particular college (Marra et al. 2012). The participants in this survey were asked if they felt like they fit in, and whether they believed themselves to be “at home” at the institution. As can be seen below (Figure 4.15), University of Saskatchewan engineering students generally report that they have a strong sense of belonging.

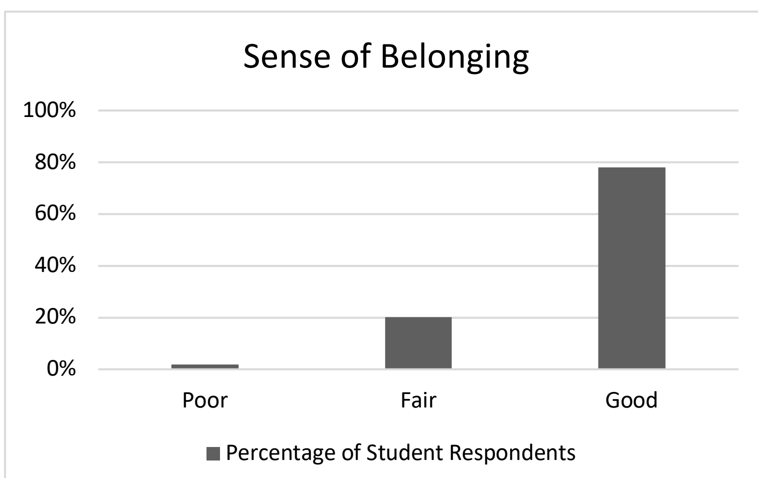


Figure 4.15: Sense of Belonging Construct Results

4.3.3.6 *Faculty Engagement*

Faculty engagement refers to the ease with which students interact with their instructors (Kuley et al. 2015). To identify if University of Saskatchewan students believe that their instructors are welcoming, the participants were asked questions about whether they were comfortable asking their instructors for help, whether or not their instructors were willing to spend time helping them outside of class, and whether or not their instructors would at the very least say hello to them if they passed each other in the hallway. This construct was analyzed/standardized, and the results are shown in Figure 4.16, indicating that most students feel generally comfortable with their instructors:

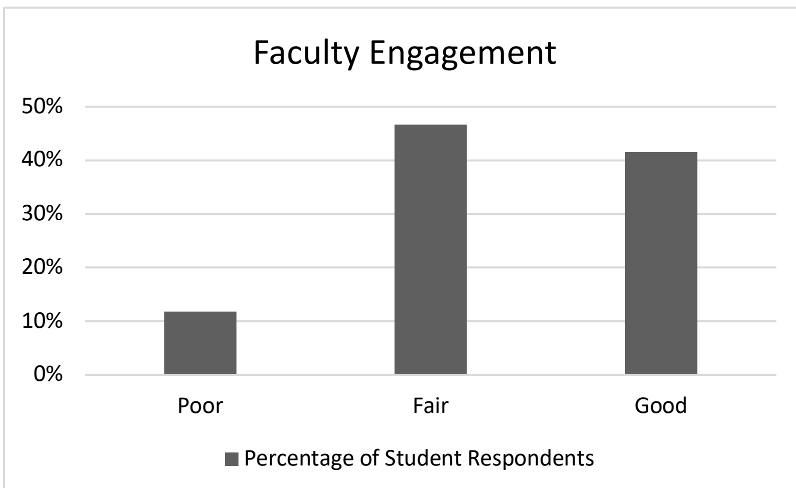


Figure 4.16: Faculty Engagement Construct Results

4.3.3.7 *Intrinsic Motivation and Attitude*

Students often have varying levels of motivation and are motivated by intrinsic factors and/or extrinsic factors, if they are motivated at all (Vallerand et al. 1992). The engineering students who responded to this survey were mostly extrinsically/externally motivated (see Figure 4.15).

Vallerand describes the different motivation types as follows (Vallerand et al. 1992):

Table 4.5: Vallerand's Academic Motivation Scale Variables

Intrinsic Motivation

To know	These students are motivated by the sheer pleasure of learning something new.
Toward accomplishment	These students engage in activities for the pleasure of attempting to accomplish or create something, they are the "overachievers."
To experience stimulation	These students aim to experience stimulation sensations, whether that be a stimulating class discussion or reading an engaging book.

Extrinsic Motivation

External regulation	The most readily understood extrinsic motivation type, refers to students whose behavior are regulated through external means, such as rewards or constraints, i.e. "I'm going to study because my parents will get upset if I don't."
Introjected regulation	These students begin to internalize the reasons for their actions, but they are motivated by external sources, i.e. "I'm choosing to study because that is what good students do."
Identified regulation	These students further internalize their reasons for studying/working hard in their classes to the point where they identify with the task, i.e. "I've chosen to study because it is important to me."

Amotivation

These students do not connect their own actions to the outcomes they receive. They are neither intrinsically nor extrinsically motivated, and perceive their behaviors as being caused by forces outside of their control.

The conglomerate results of participants' responses to the Academic Motivation Scale (AMS) 28 are shown in Figure 4.17:

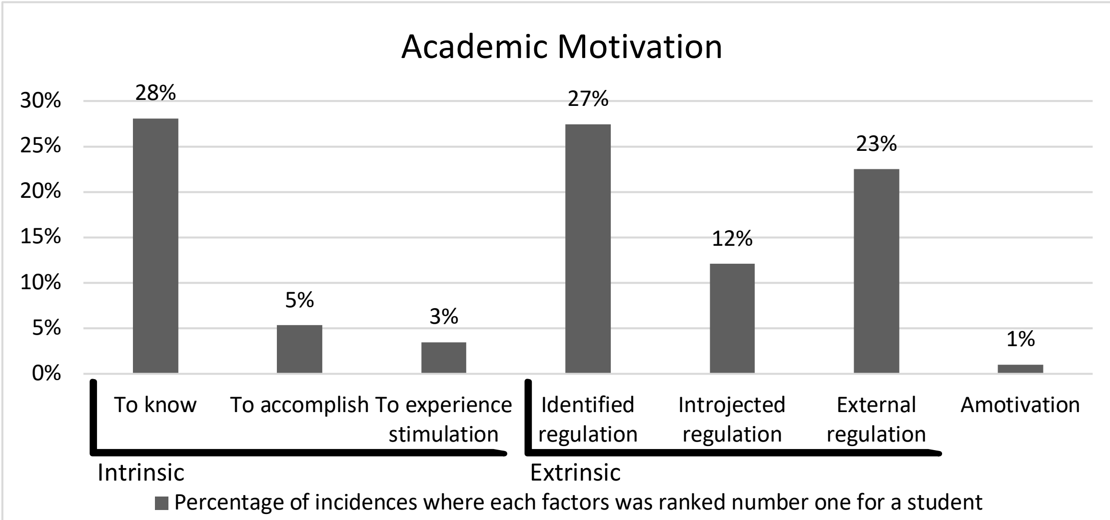


Figure 4.17: Academic Motivation Construct Results

4.3.3.8 Self-Efficacy

Self-efficacy has long been understood to affect student performance and persistence, especially in minority students, including females (Rose & Kelly 2009; Hutchison-Green et al. 2008). To assess students' self-efficacy, Pintrich's self-efficacy scale from the Motivated Strategies for Learning Questionnaire (MSLQ) was employed and scored as directed (Pintrich et al. 1991). Results are shown in Figure 4.18.

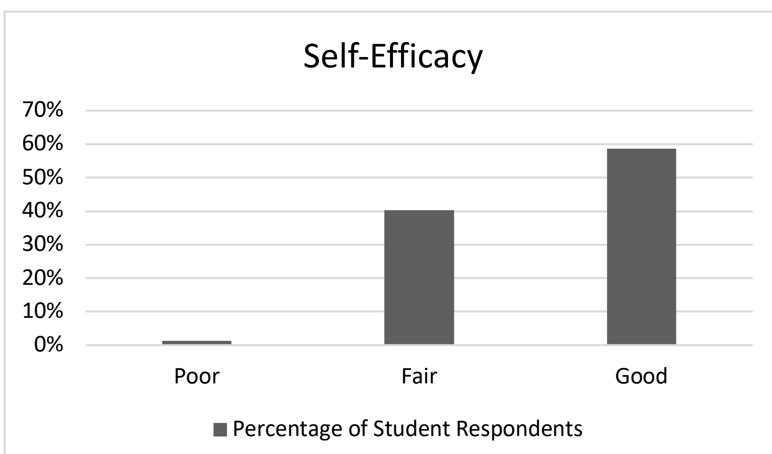


Figure 4.18: Self-Efficacy Construct Results

4.3.4 Inferential Statistics

Although the intent of this research was to develop a logistic regression model that would predict the characteristics of a student who was most likely to persist in the college through to graduation, the data was not appropriate for such a test.

As predicted by the literature review, many of the factors that were measured are highly related to one another, therefore not meeting the necessary assumptions of a regression analysis and rendering the findings from such a test invalid. This phenomenon is known as multicollinearity, wherein the dependent variables (constructs and factors believed to impact attrition/retention) are interrelated, and thus their unique impact on the independent variable cannot be properly distinguished and measured. The table below is a correlation matrix that outlines the statistically significant correlations between all dependent variables.

The high amount of multicollinearity in this data makes it difficult to parse out which factors have the most impact on student decisions to leave the College, indicating that it is likely a combination of these factors working together that causes a student to leave.

Table 4.6: Pearson Correlation Matrix

		Faculty Engagement Construct	Cumulative Degree Average	Admittance Average	HS Math Grade	HS Physics Grade	HS Chemistry Grade	HS English Grade	Sense of Belonging	Motivation 'To Know'	Accomplishment Motivation	Stimulation Motivation	Identified Motivation	Introjected Motivation	External Motivation	Amotivation	Self Efficacy	Grit	Institutional Climate	Curriculum Construct
Faculty Engagement Construct	Pearson Corr.	1	.154*	-.170**	-.099	-.056	-.062	-.210**	.252**	.223**	.222**	.331**	.125*	.083	-.030	-.026	.294**	.039	.400**	-.122*
	Sig. (2-tailed)		.026	.002	.086	.339	.283	.000	.000	.000	.000	.000	.022	.128	.585	.633	.000	.483	.000	.027
	N	333	209	331	303	298	301	298	333	333	333	333	333	333	333	333	333	333	333	333
Cumulative Degree Aveage	Pearson Corr.		1	.323**	.494**	.404**	.419**	.334**	-.045	.227**	.273**	.141*	.069	.045	-.023	-.036	.368**	.083	.013	-.231**
	Sig. (2-tailed)			.000	.000	.000	.000	.000	.517	.001	.000	.040	.313	.513	.737	.601	.000	.218	.852	.000
	N		231	229	214	208	209	210	209	214	214	214	214	214	214	214	231	221	209	231
Admittance Average	Pearson Corr.			1	.616**	.599**	.543**	.665**	-.011	.052	.061	-.066	-.049	-.032	-.046	.021	.039	-.034	-.072	-.117*
	Sig. (2-tailed)				.000	.000	.000	.000	.845	.344	.264	.226	.368	.555	.394	.695	.463	.523	.194	.026
	N			363	330	323	325	323	331	339	339	339	339	339	339	339	363	348	331	363
HS Math Grade	Pearson Corr.				1	.699**	.723**	.550**	.023	.060	.068	-.028	.005	-.031	.070	.036	.164**	.025	.006	-.092
	Sig. (2-tailed)					.000	.000	.000	.690	.288	.233	.620	.931	.581	.219	.531	.003	.658	.912	.094
	N				332	325	327	325	303	311	311	311	311	311	311	311	332	318	303	332
HS Physics Grade	Pearson Corr.					1	.575**	.538**	.042	.121*	.114*	.007	.036	.012	-.007	-.004	.146**	-.045	-.015	-.090
	Sig. (2-tailed)						.000	.000	.470	.035	.046	.910	.537	.840	.898	.950	.009	.427	.800	.106
	N					325	323	320	298	305	305	305	305	305	305	305	325	311	298	325
HS Chemistry Grade	Pearson Corr.						1	.510**	.096	.096	.086	.031	.062	-.017	.100	-.023	.174**	.091	.053	-.109*
	Sig. (2-tailed)							.000	.098	.093	.132	.592	.281	.764	.080	.693	.002	.107	.360	.049
	N						327	322	301	308	308	308	308	308	308	308	327	313	301	327
HS English Grade	Pearson Corr.							1	-.051	.040	.060	-.088	.016	-.010	.043	.001	.009	.010	-.131*	-.107
	Sig. (2-tailed)								.376	.481	.294	.126	.777	.865	.449	.991	.865	.856	.024	.053
	N							325	298	306	306	306	306	306	306	306	325	311	298	325
Sense of Belonging	Pearson Corr.								1	.325**	.267**	.338**	.342**	.219**	.176**	-.363**	.313**	.272**	.648**	-.194**
	Sig. (2-tailed)									.000	.000	.000	.000	.000	.001	.000	.000	.000	.000	.000
	N								333	333	333	333	333	333	333	333	333	333	333	333
Motivation 'To Know'	Pearson Corr.									1	.657**	.704**	.455**	.320**	-.037	-.377**	.416**	.153**	.429**	-.042
	Sig. (2-tailed)										.000	.000	.000	.000	.492	.000	.000	.005	.000	.442
	N									341	341	341	341	341	341	341	341	340	333	341
Accomplishment Motivation	Pearson Corr.										1	.697**	.439**	.622**	.152**	-.218**	.339**	.176**	.356**	-.003
	Sig. (2-tailed)											.000	.000	.000	.005	.000	.000	.001	.000	.955
	N										341	341	341	341	341	341	341	340	333	341

Continued.

CONTINUED		Faculty Engagement Construct	Cumulative Degree Average	Admittance Average	HS Math Grade	HS Physics Grade	HS Chemistry Grade	HS English Grade	Sense of Belonging	Motivation 'To Know'	Accomplishment Motivation	Stimulation Motivation	Identified Motivation	Introjected Motivation	External Motivation	Amotivation	Self Efficacy	Grit	Institutional Climate	Curriculum Construct
Stimulation Motivation	Pearson Corr.											1	.456**	.445**	.095	-.147**	.320**	.084	.393**	.022
	Sig. (2-tailed)												.000	.000	.081	.007	.000	.120	.000	.680
	N											341	341	341	341	341	341	340	333	341
Identified Motivation	Pearson Corr.												1	.447**	.454**	-.268**	.235**	.179**	.314**	-.079
	Sig. (2-tailed)													.000	.000	.000	.000	.001	.000	.144
	N												341	341	341	341	341	340	333	341
Introjected Motivation	Pearson Corr.													1	.345**	-.041	.142**	.091	.259**	.025
	Sig. (2-tailed)														.000	.448	.009	.095	.000	.651
	N													341	341	341	341	340	333	341
External Motivation	Pearson Corr.														1	.078	-.006	.095	.077	-.044
	Sig. (2-tailed)															.150	.911	.082	.163	.415
	N														341	341	341	340	333	341
Amotivation	Pearson Corr.															1	-.258**	-.357**	-.353**	.025
	Sig. (2-tailed)																.000	.000	.000	.642
	N															341	341	340	333	341
Self Efficacy	Pearson Corr.																1	.218**	.343**	-.087
	Sig. (2-tailed)																	.000	.000	.096
	N																365	350	333	365
Grit Scores	Pearson Corr.																	1	.211**	.017
	Sig. (2-tailed)																		.000	.752
	N																	350	333	350
Institutional Climate Score	Pearson Corr.																		1	-.153**
	Sig. (2-tailed)																			.005
	N																		333	333
Curriculum Construct	Pearson Corr.																			1
	Sig. (2-tailed)																			
	N																			365

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

4.4 **Qualitative Analysis of Full Survey**

In the mixed methods approach used in this study to cross check findings from various sources, the qualitative analysis of the full survey provides a deeper understanding of student perceptions and answers, as shown below.

The qualitative portion of the full survey was designed using the Stop-Start-Continue technique for speaker feedback as categories for obtaining student feedback about the College. This framework aims to identify, in a broad sense, what you should stop, start, and continue to do from a user perspective, and is used to encourage constructive qualitative feedback that is of greater depth and usefulness than less structured feedback approaches (Hoon et al. 2015). In this application, the Stop-Start-Continue method was used to identify, in relation to student success, the following: barriers that students report need to be addressed, ideas that students have to improve the College in whatever way they believe to be most appropriate (culture, curriculum, etc.), and processes/programming that students report are done well and should remain.

The results of each question are highlighted below. It should be noted that these questions were answered by students and the data is thus a representation of student experience; as such, their direct quotes were included as much as possible to ensure that their authentic voice came through for interpretation.

4.4.1 Stop

To identify the processes, facilities, and people that students believe act as barriers to their success, i.e. what the College should "stop" doing, they were asked to identify if there was anything specific that came to mind when they thought of potential barriers to their success in engineering. After coding 180 viable (non-blank) answers and grouping them into similar themes, it was found that the students' answers could be applied into the categories that emerged from the literature review: student, instructor, and college level (Kuley et al. 2015) answers. These categories were adapted from what Robert Marzano calls the three levels of factors that influence elementary and high school effectiveness (Marzano 2003).

There were approximately 30% of responses that related to each of the three levels, and an additional 9% of participants indicated that they did not have, or could not think of any barriers. The following sections describe the themes that emerged from this data set within the student, instructor, and college levels:

4.4.1.1 Student Level

Student level factors include those that are individual to a student, and though these factors can be influenced by instructor and college level intervention, they are primarily related to individual learners. Several themes emerged that had to do with barriers that currently exist for students.

The first theme that came out of the data suggested that students perceive the curriculum as inflexible and "impossible to have school-life balance" and "unwelcoming… for students who have additional responsibilities" (n = 17/180), with one student noting that "engineering is definitely not meant for someone with kids." Students reported that they could not achieve a good school/life balance (staying fit, maintaining friendships, and managing the transition from high school) and still get good grades – engineering students have been told in their initial first-year course, "sleep, friends, grades… choose two," which reinforces this idea.

A portion of students also identified that being academically unprepared is a barrier that exists for them (n = 15/180). The high school courses offered (and their quality) to engineering students differ from region to region, even within the same province (Global News 2017; CBC News 2018; Conference Board of Canada 2014).

4.4.1.2 Instructor Level

Potential concerns about course instruction in engineering programs came up in two ways, one relating to the quality of instruction (n = 30/180) and one relating to faculty engagement (n = 12/180).

There is a strong link in the literature between students reporting that their instructors care about them as people, and their persistence/success in a program (Heller et al. 2010; Christe 2013; Vogt 2008). The participants echoed the literature; when they report that their instructors make them “feel unwelcome” and seem to not care about teaching their courses, they reported finding it difficult to stay engaged. Thirty participants, 7 first-year students and 23 upper-year students reported that the quality of instruction in their program is a barrier to their, and their peers’, success and often reported a desire for instructors to “show [that they] care.” They highlighted issues relating to unclear explanations of concepts, ambiguity in marking scheme, and a lack of resources available for them to teach themselves the concepts should the instructor not teach in a way that suits their learning style.

4.4.1.3 College Level

College level factors (particularly workload) were most cited by students as acting as barriers to their success, though it is impossible to separate college level themes entirely from one another or from other levels, as they are inextricably linked.

One college level barrier that emerged was the culture of first-year undergraduate students (n = 15/180). Some students reported that large class sizes were intimidating to them and made them “feel like a number”, which made it difficult for them to identify with their institution and to develop a sense of belonging. In addition to this lack of belonging, students identified a trend among their peers, wherein (some of) their peers do not want to excel in their program. They indicated that other students simply wanted to ”just get by” and “survive” their undergraduate degree, emphasizing the “Cs get degrees” mentality, which they reported was demoralizing for them.

Another barrier that was identified was the abstract nature of the first-year curriculum, and the perception that they cannot manage the heavy/rigorous curriculum of engineering while still learning the material well (n = 52/180). Students found it difficult to see the relevance of the curriculum to both their chosen discipline and to working in industry or research, citing that there are “not enough real-world job skills taught.” This is a problem that is noted in modern engineering education literature as a pronounced cause for student attrition (Froyd & Ohland 2005). Students reported wanting to have the time to better understand the material, but reported having to pick and choose what they learned, while simultaneously “not having a social life” and “sacrificing so much of [their] personal time.”

4.4.2 Start

Students were asked, “What could the College do/change to make first-year more successful for engineering students?” In other words, what could the College start doing that would help them? There were 210 viable responses to this question, ranging from programming suggestions to events that the College could run. Many of their answers from the Start portion of the survey were essentially their solutions to the problems that they identified in the Stop portion of the survey. Because this was an ideation question, many ideas were received and suggested by multiple respondents (5 - 15). The top suggestions (greater than 25 respondents) revolved around instructors, college culture, and curriculum/workload, and will be discussed further.

4.4.2.1 Instructor Resources

The most prominent construct that emerged from the data revolved around improving quality of instruction and faculty engagement, particularly in first-year (n = 37/210). Students noted that colleges should put their best and most engaged teaching faculty in first-year education, which in turn would benefit the entire institution by ensuring first-year students are provided with a solid understanding of fundamental material. Upper-year students in particular noted that as they moved on in their program, they reported that their professors “cared more” and were invested in their success, and believed that it helped them in their program.

Participants indicated that they wanted to be able to effect positive change in their college, and that “evaluations [of college programming] should be compulsory.” They expressed concern that the evaluations that are currently being conducted are not being listened to and asked that the College “change [instructors] for classes when they get poor evaluations.” Another asked the College to “provide training for [instructors].”

4.4.2.2 Improving College Culture

Twenty-nine (n = 29/210) talked about peer networking, mentorship, and finding other ways to help students connect and make friends. They reported these bonds as being integral to the success of engineering students (especially first-years). They also suggested that the College “promote a sense of unity by investing in student groups,” and “have more group work in first-year, [because] friends are essential.”

Engineering students report feeling intense pressure to perform and suggested that it would benefit them to have more access to mental health counselling and support available. It was also suggested that the College facilitate positive interactions between faculty and students, indicating that it would improve their sense of belonging. Other students suggested that peer networking be encouraged, and two students suggested that a mentorship program be created.

A detractor that students discussed was the existence of a “weed out culture” that discourages students and perhaps hinders their performance. The concept of “weeding students out” or “getting rid of poor performers” is evident in the data; many students appear to be under the impression that engineering colleges try to weed them out rather than support them in their engineering career. One student stated that the College should “reconsider the weed-out process as it is inefficient.”

4.4.2.3 Curriculum/Work Load

The engineering curriculum is rigorous and heavy. Students reported having barely enough time to do the assignments each week, and that the heavy workload was not conducive to better learning (n = 27/210). They could then not see the value in putting in the effort required to persist. They were often specifically not asking for easier work, but rather to have enough time to better grasp the concepts and to have assignments that aligned with exam assessments in terms of difficulty and course material.

4.4.3 Continue

When asked “is there anything in your engineering degree so far that you feel is done well and helps students succeed?” nearly 50% (n = 103/221) of students responded positively to tutorials and help sessions. This suggests that students appreciate the time/effort that colleges invest in academic student support services.

The U of S College of Engineering implemented an initiative in Fall 2015 called ‘facilitated study sessions’ that students mentioned specifically as something that the College should continue (n = 53/221). In these help sessions, students are invited to spend 2-3 hours doing homework and/or studying any first-year engineering subject, and are assisted by a peer mentor (teaching assistant/facilitator) when they have questions. There is one facilitator available for each first-year engineering course, giving students access to immediate help and feedback regardless of what they are working on.

4.5 **Interview and Focus Group Thematic Analysis**

Interviews were conducted prior to any analysis being conducted on the full survey – the purpose of this concurrent mixed methods approach was to identify if similar themes emerged from both quantitative and qualitative data, and if not, to identify where they differed.

After transcribing five interviews and one focus group conversation, these transcripts were analysed to determine if there were any similar trends that existed between students who were struggling in their classes or those who were succeeding, as well as to identify any themes in their perception about the College.

4.5.1 Student Perceptions of Their College

Overall, students tended to say very positive things about the institution. Since the students interviewed all persisted in the College, it is worth noting that each student interviewed indicated they had a close peer network. Students said things like, “it is one of the best schools for engineering,” “I feel like it’s practical... the whole program,” and “The College has definitely done well with their engineering courses.”

One idea that came up in the transcriptions was that the College intentionally “weeds students out,” though they indicated that they “understood why they are doing it the way they are.” One student indicated that a close relative “actually said the reason that first-year engineering is hard is because they're trying to pick off which ones will be the best out of the 600 of you.” The concept that the College weeds students out to, as one student put it, “take their tuition money before cutting them in half,” came up in all but one of the interviews, unprompted. When a follow up question was asked about where this idea came from, it was either relayed to them by a parent or engineering mentor or, they said, that it was just *known*.

4.5.2 *Transition from High School*

Students reported in the interviews that the transition between high school and university was very difficult; “the workload, and being totally unprepared for it,” may be a barrier to success for themselves and their peers. One student said, “I knew I would have to study more, do more homework, but I didn't realize how much it was going to be. It kinda just shocks you almost.”

The students also noted that they were unaware of their lack of preparation until after their midterms, at which point they believed that it was too late to truly learn the material well and catch up: “I wasn't used to how hard I had to work and I didn't really realize until midterms.” This idea came up more for students who were struggling in their courses and not at all with the students who were in the top of their class.

4.5.3 *Curriculum and Workload*

Echoing the survey data, as well as Engineers Canada’s student exit survey (Engineers Canada 2017), every single interviewee discussed at length the difficulty in managing their course work. Even the strongest students said things like, “first semester was great in terms of marks… but I put on a tonne of weight and I was always stressed and I was never fun to be around.” One student mentioned that he had a family member who went through engineering and the only way “he and his friends survived was by copying one another’s assignments,” because it was impossible, they reported, to do the work in the amount of time that they were given. Another said “there is enough time to do all the work. You just won’t be hanging out with friends or spending much time sleeping.”

4.5.4 *Teaching Influence*

It matters to students that their instructors *care* about their success, and about the subject matter they teach. They brought up positive experiences and negative experiences, but overall their emphasis is what stood out.

When talking about their general engineering first-year courses, one student said “It’s not just that they are good teachers because they are engineers, but because they like it…. [my professor] would adjust if we didn’t understand the way he was saying something because of his accent. So that is a good professor, he's trying to teach and teach well. That's cool, I loved that, and I loved that class." In contrast, another student described why they believed that an instructor's enthusiasm matters: "Having someone care what happens to you would help you do better," and "it would definitely make me feel like they're not trying to make us fail, which I do feel a lot." Another recognized that this was important to them, saying "One of the biggest barriers for me personally is the lack of… not passion, but care a professor has when the classes are this big. It's not really their fault because they can't really try to learn everyone's names when there are 600 students total in a year and when half of them are going to be gone anyway."

4.5.5 What Makes Students Persist

The individual interviews were conducted with students who were more likely to leave the College based on their academic averages, but since none of them ever did leave the College, an opportunity extended itself to understand what, potentially, encouraged them to stay in the College. As it turns out, these students were quite similar in a few ways that the literature suggests enables students to persist in their academic goals, despite their academic struggle early on.

They all had a role model and a mentor who was an engineer – and these students reported that their mentors often soothed students' anxieties that they were alone in finding the program difficult, relaying stories from when they went through the program. They also had a strong social network and "lots of friends in the program" who helped them feel as though they belonged there, despite their academic struggles at the time. They were also all urban students, who are more likely to succeed in their engineering program as shown above.

Each of these interviewees had decided on engineering early on in their lives, exhibiting a high level of grit in achieving their long-held goal. One student said that "Engineering is what I've wanted to do since I was a kid, so if I get a really low mark on something, the College would have to drag me out before I left," and another said "It's what I like to do, is what it comes down to. If it's hard and painful and frustrating and unfair, so be it."

5 Triangulation of Results

In the application of concurrent-triangulation mixed methods research, the researcher collects both qualitative and quantitative data, assuming equal importance of both data types. These sources are analysed individually before the results are compared, also known as data triangulation (Creswell & Plano Clark 2011; Borrego et al. 2009). In this concurrent-triangulation mixed methods study, five data sources were used: one qualitative dataset including interviews and a focus group discussion, one quantitative database of student data, and two surveys that included both qualitative and quantitative data.

Although, individually, these data sources provide their own valuable insights, the convergence of data upon the most prominent themes provides further evidence that these themes should be further investigated. This section highlights themes identified in each data source and discusses the three major themes that emerged.

5.1 Theme Convergence

As indicated in Table 5.1, the themes that recurred across all data sources were: peer influence and sense of belonging, faculty engagement, and curriculum/workload. The factors that emerged from the systematic literature review were supported by the data, which is known as "cross-validation," or "convergence" (Creswell & Plano Clark 2011). Note that the historical database did not include any non-cognitive variables (only academic and demographic data) for students. This convergence on themes that emerged from the systematic literature review corroborates and supports the use of this review as a framework (Figure 3.1).

The themes that recurred across all data sources were: peer influence and sense of belonging, faculty engagement, and curriculum/workload. These themes will be discussed further in Section 5: Triangulation of Results.

Table 5.1: Literature Review Factors Identified in Data Source Themes

		Historical Data	Pilot Survey	Quantitative Full Survey Data	Qualitative Full Survey Data	Interviews and Focus Group
		QUANT	**QUANT (qual)**	**QUANT**	**QUAL**	**QUAL**
College Level Factors	Institutional Climate			X	X	
	Curriculum/ workload		X	X	X	X
	Engineering Mentorship			X	X	X
	Peer influence/sense of belonging		X	X	X	X
Instructor Level Factors	Faculty Engagement		X	X	X	X
	Professional role modeling					X
Student Level Factors	Academic Achievement	X				
	Learning Style				X	
	Intrinsic Motivation			X		
	Self-efficacy			X	X	
	Demographics	X				

5.2 Peer Influence and Sense of Belonging

Many students reported feeling welcomed and that they "fit in" with their peers (almost 80%), It should be noted that the demographics of this student population are skewed (the majority of students are Caucasian males), which may lead to a stronger feeling of belonging among the majority group, as it is easier to find connections in more homogeneous groupings.

Qualitative responses that focused on their sense of belonging to the institution rather than their peers diverged, wherein students indicated an "us vs. them" mentality at times. The perception of "weed out culture" emerged in all qualitative data sources; having this belief lowers student self-efficacy, thus making them more likely to drop out of university altogether

(Haag et al. 2007; Geisinger et al. 2013). One student stated that they had heard numerous times that "[they] were the worst first-year class ever," and reported that "[first-year] engineering [was] portrayed as impossible," while another said that they "did not feel welcome." Students reported that "it does genuinely feel like they are trying to fail us" when discussing one first-year course in their survey response. Another said in an interview, "they're trying to pick off which ones will be the best out of the 600 of us."

At the same time, the College is working diligently to retain students and to invest in their success; however, data indicates that students do not know that this investment is being made. In fact, many students indicate that they believe the College is intentionally "weeding [students] out" in an effort to only allow the "cream of the crop" into second-year.

5.3 **Faculty Engagement**

Students tend to achieve better learning outcomes in courses where the instructor is passionate about the subject that they are teaching and when the students feel that their instructors want them to succeed (Kuley et al. 2015). This may be particularly true for these participants, who are largely (63%) externally motivated, since these students tend to focus most on getting grades and recognition from their professors (Gasiewski et al. 2012).

Instructors were reported by participants to be a positive factor in student success (n = 30/221), while poor instruction was listed as a barrier to student success. Students indicated that instructors have an impact on their success in engineering programs, for better or worse, which again highlights the individual nature of student experience. It is concerning, given the knowledge that instructors play a significant role in student outcomes, that some students perceive them to "not care about teaching."

Another important factor in the faculty-student relationship is the representation of minority groups in faculty and as role models (Chubin et al. 2005). Students look to faculty to guide their learning and to act as role models for them. If none of the faculty look like a particular student, that student may start to feel as though they don't belong in that space (Foor et al. 2007).

Many students will not see themselves represented by faculty in the College at the time of this thesis publication.

It should be noted that teaching assistants (TAs) in engineering colleges also play a consequential role in student learning. One first-year student who was struggling in their program said, “the one TA, I would ask them a question and they would give me an answer on how to approach the problem and it would be totally wrong. That would affect my mark because I trusted [that TA] at first.” This sentiment was echoed in the focus group discussion with academically strong students who said succinctly, “some TAs are helpful and know what they are doing. Students in those labs probably do better. Some TAs just write their notes on the board and sit at the front because they can’t answer questions or don’t care.” If TA quality is not assessed or managed, it may have an effect on a first-year cohort (Haag et al. 2007).

5.4 **Curriculum and Workload**

College level factors are perhaps the most important factors to acknowledge as literature suggests that college level factors can influence both instructor level factors and student level factors (Marzano 2003). In several of the analyses conducted, students reported finding it difficult to balance their course work alongside their personal lives, highlighting examples such as social activities, familial responsibility, jobs, volunteering, etc. This was evident in the full survey quantitative data, wherein students give curriculum/workload in the College a rating of “poor” (n = 183/365). Student respondents found it difficult to manage their workload as part of their day-to-day lives. Additionally, 52/180 respondents to the full-survey indicated in their qualitative responses that they felt the curriculum was either too heavy or that they could not see the connection between their learning outcomes and their chosen career paths. This theme emerged again in interview discussions where students reported feeling overwhelmed and that they could not adequately learn the material without sacrificing necessary components of a healthy lifestyle. College level factors are by far the most prominent factors affecting student success, and have an impact on all subsequent variables (Marzano 2003; Kuley et al. 2015).

Both literature and participant data showed that many students have additional family/personal circumstances that require their time, and/or financial barriers that make it necessary for them to work. Unfortunately students were not asked directly whether or not they work part time, but many indicated in qualitative responses that this was a significant barrier to their success in their programs. Engineers Canada's student survey also indicated that over 60% of engineering students have to work alongside their studies (Engineers Canada 2017).

Students also reported not feeling prepared for the significant jump in workload from high school to university, which perhaps exacerbated their feelings of being overwhelmed. Engineering students historically have needed to be the best and brightest students in their high school and are, as one student put it, "not used to having to work to succeed." The data suggests that many students had not been challenged up until they reached their first-year of engineering. Being mentally and emotionally unprepared for the transition into university was identified by 27 participants as a barrier to their success in the full survey. Poor study habits and lack of motivation were reported, as were high levels of stress and anxiety, which are made worse as they were, as two students specifically stated, "made to feel stupid" in their first-year of study. If there is any benefit to students feeling overwhelmed in their first-year, it has not been found in the literature and it has not emerged through these analyses.

6 Discussion

The factors identified as impacting student success and/or persistence that were most pronounced in this sample population included: peer influence and sense of belonging, faculty engagement, and curriculum/workload. These factors were identified through a systematic literature review as being predictive of student persistence, and prominently appeared in multiple datasets in this mixed methods study.

6.1 Peer Influence and Sense of Belonging

The perception of “weed out culture” emerged in all qualitative data sources; having this belief lowers student self-efficacy, thus making them more likely to drop out of university altogether (Haag et al. 2007; Geisinger et al. 2013). Students who hear that they are in the “worst class” and that first year engineering is “impossible” may find it difficult to feel encouraged in their program. In fact, it is likely why students said things like, “[I] did not feel welcome” and that they felt as though they were being intentionally undermined.

While some students (particularly upper-year students) indicated that they felt welcomed and supported by their instructors and the College as a whole, another subset of students indicated a perception that they were “set up to fail” in their program and that “some instructors wanted [them] to fail.” This, of course, is an example of the highly contextual and individual nature of student experience supported by the constructivist perspective outlined in the Quality Criteria for Qualitative Inquiry section of this thesis.

Students who meet friends early on in their program and feel welcomed, build a sense of belonging and are then more likely to stay in a college and to graduate as engineers (Danielak et al. 2014). This idea was supported in interview data, with students who were academically struggling but persisted in the College, indicating that they were already invested in their programs through friend networks and that the College would have to “drag them out” to get them to leave.

6.2 **Faculty Engagement**

Students reported that it not only made them feel more comfortable when an instructor "cared" about them, but noted that it helped them achieve better outcomes in class. Interview participants discussed the impact that their instructors had on them as well through stories about particular instructors who were passionate about the subject that they taught, or who had a negative impact on that student's semester. This data supports literature findings that instructors who show a level of care for their students also increase the likelihood of those students persisting in their program (Christe 2013; Hong & Shull 2010), and that the instructor/student relationship heavily impacts student success (Vogt 2008).

Disengaged faculty who show up and write notes on the board will not deter intrinsically motivated students who push themselves to learn, but they will demotivate students who are extrinsically motived. Students reported that it is important to them that their instructors place value on teaching well, are knowledgeable about the subject matter, and that their instructors are invested in student success. If a student reported that it was important to them that their instructor wanted them to succeed, and if that same student is identified as externally motivated, then it is likely that they will improve their performance as their instructor pushes them to challenge themselves to learn.

6.3 **Workload and Curriculum**

Researchers and engineering college alumni, agree that the first-year engineering curriculum is often very abstract, theoretical, and lacks context for students who crave "real world" applications, which potentially affects a student's decision to stay or leave their college (Froyd & Ohland 2005). This is unfortunate as it does not accurately showcase engineering as a profession and, thus, students who would both enjoy and excel as an engineer are potentially lost. When students fail to see the relevance of that workload to their career, academic or professional, they find it difficult to stay engaged and are more likely to leave the College (Froyd & Ohland 2005).

Engineering students reported a belief that the heavy workload in first-year engineering is there to weed out a certain percentage of students in both surveys and interviews. This not only positions the College as an adversary, and "out to get them," as one student said, but acts as a driver for student attrition (Haag et al. 2007).

A heavy workload and rigid/abstract curriculum will impact students from various sub-groups depending on their individual backgrounds and experiences (Ohland et al. 2011; Danielak et al. 2014; Foor et al. 2007). These variations in individual experiences have begun and will continue to emerge in the classroom; for example: students who have taken advanced calculus with an excellent teacher and those who took calculus via correspondence, students who take off their summer vacations off to go travelling and those who need to work to ensure they can pay for tuition the next year, students who learn best through lecture-style teaching and those who need to physically work through a problem before understanding, etc. Students reported in all datasets that they felt that their programs were rigid, and the workload was too much to balance with other activities, which also disadvantages students who have additional responsibilities: athletic competitions, care taking for dependents, students transitioning to living on their own for the first time, etc. Note that these "additional responsibilities" are often unavoidable, and may be beneficial to a holistic student experience. For example, students who have children may struggle with the workload without a clear opportunity to lengthen their program; this rigidity may even preclude some from attending the College at all.

6.4 **Limitations**

Participants will often not be able to identify key factors that are acting as a barrier to their success, as they can only see the situation through their own perspective, missing the greater context and contrasting instances. For example, if student 'A' has an excellent high school math teacher, they may find first-year easier than student 'B' who had to take high school math through correspondence and had to teach themselves. If student 'B' is asked what the barriers to their success are, they may say "I'm bad at math" or "I'm lazy," internalizing their struggle with the subject rather than recognizing or acknowledging external factors at play.

This discrepancy is why, after the pilot survey, the methodology was modified to measure non-cognitive variables in students and to attempt to correlate those factors to persistence/attrition, rather than solely asking students directly. It is not only important that engineering colleges know that students of a certain demographic struggle, but *why* they might struggle. Otherwise, colleges are at risk of misidentifying correlation with causation, and can dangerously paint all students of a demographic as ‘not a good fit,’ when there may be an external barrier that could be removed.

This study enabled the researcher to corroborate much of what other research has found and identified a useful framework with which to identify areas where engineering colleges need to focus attention. Due to the nature of the study, however, it cannot be definitively said that the identified factors are causing attrition, rather, that they may contribute to student attrition based on previous findings identified in the systematic literature review.

Other limitations on this study methodology included:

- Lack of contact with students who left the College. Emails were sent to students who had left the College, but none of these students responded. To address this sampling gap, future studies could target students who have left their college.
- Survey responses were non-longitudinal, capturing student perceptions at a moment in time. Barriers/supports may have arisen or become salient later. For example, even if some of those students left at a later date, they may not realize what barriers existed for them until after they’ve decided to leave the College or were academically unsuccessful. Future longitudinal studies would provide a deeper understanding of student choices as it would allow researchers to see how participants’ perceptions adjust over time.
- Small sample size of qualitative data from interviews. Although a significant size was obtained for our full survey (both qualitative and quantitative data), additional interviews may have provided supplementary analysis. Future studies might use an iterative mixed methods approach wherein the findings are brought back to student participants for verification.

Given how closely the data aligns with findings from the Engineers Canada report and this study's literature review, the transferability and trustworthiness of this study is substantial, but its applicability would be bolstered by a multi-site study (assessing barriers to success at multiple institutions for comparison). A multisite study would be beneficial, as it would allow researchers to see which factors emerge most prominently in different contexts, when an institution has different student population demographics, faculty members, and college climate. Obtaining more interview data and recording thick descriptions would also increase the trustworthiness in any future studies.

7 Recommendations

Engineering colleges may want to assume that the best engineers are the students who succeed in their programs as they have been designed; however, this is likely not the case (Ohland et al. 2011; Froyd & Ohland 2005). Given the history of many engineering colleges, it is more likely that engineering programs are catering to a particular type of student, rather than those students being the "best" possible students (Danielak et al. 2014; Froyd & Ohland 2005). The central adjustments that could be made based on the corroborated framework relate to the most prominent factors that impact student retention: *faculty engagement, sense of belonging*, and *curriculum/workload*.

Faculty can have a remarkable impact on student retention. Vogt indicated that "faculty should be more accessible to students in ways that generate positive and welcoming interaction," but that the "teaching and education" portions of tenure applications often do not account for this level of commitment to student success (Vogt 2008). If colleges wish to retain more engineering students, they need to highlight the importance of positive instructor/student relationships to student success (Theall 2005) and encourage professors to build a positive rapport with their students. Christe summarizes in her literature review on the subject, "Strong scholarly evidence supports an approach to retention that encourages professors to connect to their students," and that colleges "must drive a change in academic culture away from survival of the fittest to a nurturing experiences that supports achievement" (Christe 2013).

Increasing student sense of belonging is impacted by faculty interactions, but also by the environment in which students learn. Although having a role model did not come up specifically in this study in relation to a student's sense of belonging, the literature supports that minority students achieve better outcomes when they are represented at a faculty level and in industry (Chubin et al. 2005; Gunzenhauser & Gerstl-Pepin 2006). Therefore, to create a strong sense of belonging for a broader range of students, it would be prudent for engineering colleges to invest in hiring diverse faculty and staff who represent the college demographic that they hope to achieve.

Increasing engineering cohort diversity of all kinds opens opportunities for engineering college strategic enrolment management targets and enriches the profession (Chubin et al. 2005).

Engineering programs were developed for a historically Caucasian/male student body, and have remained largely unchanged over time, potentially discouraging participation from diverse students who would enrich the engineering profession, but do not thrive in this current state of engineering education. If engineering colleges adjust to the varying circumstances of their students and create some measure of flexibility in their programs, enabling students to find a better balance with their personal lives, it may open the engineering profession to a wider range of students, for example, those with families and those that need to work in order to fund their education. This is not to say that engineering colleges should make their programs easier, or "lower the bar", but rather that, in order to ensure increased success of their student body, it is important to acknowledge the varied educational quality and experience in student backgrounds and ensure that programs and supports are in place to allow for a more diverse student body to succeed.

One final recommendation centers around student workload. A demanding and inflexible workload disadvantages students who have additional responsibilities (such as families or the need to work), which could lead to these students leaving their program. Additionally, the program assumes that all students have the same level of knowledge coming in; when in reality student high school experiences vary. For example, while some students have access to high quality advanced placement calculus, some do not. If instructors assume that students have knowledge from high school that they do not have, those students are automatically at a disadvantage. To alleviate this inequity of knowledge, colleges should ensure that the workload and difficulty of engineering curriculum are made clear to first-year students without making them feel as though they are incapable, and that those students with weaker academic preparation are given the tools and resources that they need to catch up to their more prepared peers.

Additionally, engineering students struggle, particularly when the workload is so high, to put in the effort to succeed when they "perceive engineering curricula to lack relevance to current engineering practice"(Li et al. 2009). This study's data supported literature findings that students feel that engineering curricula is overwhelming, and that this demanding curriculum is causing stress to students, inhibiting effective learning (Heywood 2005). Without an understanding of how the topics they are learning relate to real world problems and the social relevance of the material, students may lose their interest in learning (Li et al. 2009; Haag et al. 2007). Therefore, a review of engineering curricula is recommended to ensure that it relates to current practice and that students can appreciate the value of what they are learning.

8 Conclusion

The purpose of this study was to identify any barriers that prevent academic success and persistence of engineering students in engineering degree programs, measured by their cumulative weighted average and retention to the College, respectively. This was done through the corroboration of a framework that was identified through the systematic literature review outlined in this thesis.

The strength of this broad mixed methods study is that the themes between various data sources converged to corroborate the framework identified through a systematic literature review. Themes were identified from the text with the goal of, as Creswell states, ‘‘[saturating] the categories—to look for instances that represent[ed] the category and to continue looking until the new information [did] not provide further insight into the category” (Creswell 2005).

The *sense of belonging*, *faculty engagement*, and *curriculum/workload* factors were identified by participants as most prominent barriers to their success. What was also apparent from analysing student data from multiple datasets, was the interconnectedness of the factors identified in the literature review. A students’ decision to persist in a college or not, is dependent on multiple factors and their interactions. It is important to understand these factors as part of a larger network of issues that can, for the most part, be affected by college level programming and culture shifts.

Engineering college leaders have an opportunity to make a measurable difference in student outcomes by placing emphasis on the importance of student learning as an investment in the future of the engineering profession. Creating a culture where teaching is rewarded and students are made to feel supported and encouraged, would be greatly beneficial to engineering colleges, individual students, and as a result, to the engineering profession.

Appendix A – Pilot Survey Questions

1. Please enter your nsid (example: abc123)
2. What was the main reason you decided to enter into the College of Engineering?
3. Engineering is a very broad profession and many students don't understand their career path going into the College. Did you understand what engineering was when you entered the College?
4. Do you think that engineering will be a rewarding career?
5. Do your professors make you feel welcome and supported?
6. How would you describe the community of students within the College?
7. Where are you most likely to study?
8. Do you feel that the engineering building is conducive to studying/learning?
9. There are many ways to be involved, and to fit in to a social group. Do you feel as though you "fit in" with other students in the College (i.e. do you have a sense of belonging)?
10. There are many ways to be involved, and to fit in to a social group. Do you feel as though you "fit in" with other students in the College (i.e. do you have a sense of belonging)? [other]
11. If you have found a friend/supportive group of other students in engineering, how big is that group?
12. How do you think that your first-term average compares to other first-year engineering students at the U of S?
13. Based on your experience, please rate the College of Engineering in the following categories: | work load
14. Based on your experience, please rate the College of Engineering in the following categories: | professor quality
15. Based on your experience, please rate the College of Engineering in the following categories: | teaching assistant/marker quality

16. Based on your experience, please rate the College of Engineering in the following categories: | tutorial quality
17. Based on your experience, please rate the College of Engineering in the following categories: | facility quality (enough space, comfortable learning environment)
18. There are many different teaching styles and methodologies. Do you feel that you learn effectively from lecture style teaching?
19. What year did you graduate high-school?
20. Do you feel that your high school coursework adequately prepared you for engineering classes?
21. Do you feel that your high school coursework adequately prepared you for engineering classes? [other]
22. Approximately how many students did you graduate high school with?
23. Based on your experience, please rate the College of Engineering in the following categories. | student centre support
24. Based on your experience, please rate the College of Engineering in the following categories. | sense of community
25. Based on your experience, please rate the College of Engineering in the following categories. | comfort approaching TAs and professors
26. Which class do you feel was the most difficult from your first-year engineering courses in the first semester?
27. Why do you feel that this course is the most difficult?
28. Are you considering leaving the College?
29. Were you advised to discontinue?
30. Do you feel that the following factors affected your decision? | lacking student center support
31. Do you feel that the following factors affected your decision? | no sense of community

32. Do you feel that the following factors affected your decision? | financial difficulties
33. Do you feel that the following factors affected your decision? | procrastination/poor study habits
34. Do you feel that the following factors affected your decision? | "culture shock" (living on your own or in a new city)
35. Do you feel that the following factors affected your decision? | lack of time management skills
36. Do you feel that the following factors affected your decision? | inadequate high-school education
37. Do you feel that the following factors affected your decision? | poor marks
38. Do you feel that the following factors affected your decision? | other
39. If other, please explain.
40. Do you feel that the following factors affected your decision? | heavy work load
41. Do you feel that the following factors affected your decision? | professor/teaching quality (methods used, such as lecture style)
42. Do you feel that the following factors affected your decision? | inadequate tutorials/help sessions
43. Do you feel that the following factors affected your decision? | facilities (not enough space, not a comfortable learning environment)
44. Do you feel that the following factors affected your decision? | engineering wasn't what I thought it was
45. Do you feel that the following factors affected your decision? | insufficient lab work
46. If other, please explain.
47. Do you feel that any of the following factors contributed to your decision to stay in the College? | strong friend/study group
48. Do you feel that any of the following factors contributed to your decision to stay in the College? | well prepared in high-school

49. Do you feel that any of the following factors contributed to your decision to stay in the College? | maturity level
50. Do you feel that any of the following factors contributed to your decision to stay in the College? | sought help from professors
51. Do you feel that any of the following factors contributed to your decision to stay in the College? | good marks so far
52. Do you feel that any of the following factors contributed to your decision to stay in the College? | time management/don't procrastinate
53. Are there other factors that you feel are important? If yes, please specify.
54. Please select your gender.
55. Please indicate your year of birth
56. How do you self-identify?
57. Is there anything else that you would like us to know about your first-year experience?
58. Do you have any ideas on how to make the first-year of engineering more successful?

Appendix B – Gender Based Analysis of Pilot Survey Data

Do Female Engineering Students Differ Academically and/or Leave The College More Than Their Male Counterparts?

Liz Kuley, M.Sc. Candidate, University of Saskatchewan

ABSTRACT: Engineering Colleges throughout Canada have been trying to increase female enrollment for decades; and while there is a significant amount of research to the contrary, there are still stereotypes that encourage the notion that there are so few female engineering students because they "just aren't as committed" or "just not as prepared." This analysis was meant to determine whether or not the female students in The Engineering College at the University of Saskatchewan differ from their male counterparts in terms of retention or first term academic success or failure, as determined by The College's 60% average cut-off. Using a Chi-Squared test, the results of this analysis determine that there is no difference in these regards between female and male students. Though further research is required, this suggests that the poor enrollment rate (18% female students) is due to other factors that will need to be identified

RESEARCH QUESTION

The College of Engineering has named increased female participation in engineering as one of their top strategic priorities. Research shows that female students perform just as well as their male counterparts (Li and Tang, 2009) despite the fact that engineering is taught in such a way that male students are more likely to identify with and thrive in (Ohland et al., 2005). there are differing opinions as to whether female students leave engineering more than male students (Li, 2007) (Hartman and Hartman, 2006). The purpose of this analysis is to see if the proportion of female students leaving The College or who have lower than 60% average differ from what would be expected due to chance/the proportion of female students in The College. This led to two distinct research questions with different data sources (both of which are highly reliable, discussed below):

1. **Do female students leave the college of engineering after one year more often than male students?**
   Data for this research question was collected from the USask Information and Communications Technology website, and can be found at the following link: http://www.usask.ca/isa/uview/. The data that was analyzed was for the 2007/2008 academic year to 2013/2014.
   Nominal Variables: Gender (M/F) and Attrition (Stayers/Leavers) N=1935

2. **Is there a higher proportion of female students who are "unsuccessful" in their first semester of University?**
   Data for this research question was collected from the Engineering Student Centre for the 2014/2015 academic year. Term one averages were separated into "below 60%" and "equal to or above 60%" because The College's cut-off average for a student to have "successfully" completed first term is 60%.
   Nominal Variables: Gender (M/F) and Student Success (above/equal to or below 60%) N=486

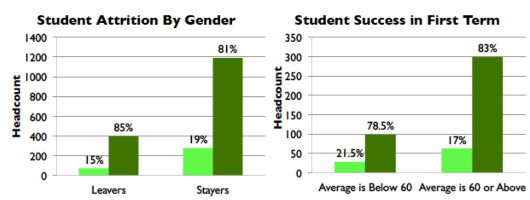
CHECKING THE DATA

In the 2014/2015 academic year, Less than 1 in 5 first year engineering students at The University of Saskatchewan were female.

Female Student Term 1 Average: 65.5%

Male Student Term 1 Average: 66.5%

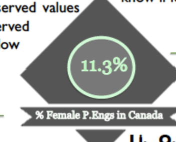
The variables used for this analysis are categorical-nominal.



ANALYSIS

Because the data was easily formed into nominal/dichotomous variables from a single population, and due to the nature of the research questions, a Chi-Squared test was deemed most appropriate. A confidence interval of 95% and an alpha value of 0.05 were employed in the analysis as that is the industry standard within engineering education.

Chi-Squared Tests are used in order to compare the observed values with theoretically expected values significant difference between the observed values and the expected values for a given question. In this instance, the observed number of female students who leave the college or have averages below 60, and what would be expected based on the proportion of female students in The College.

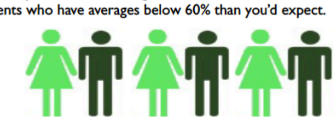


RESULTS

A chi-squared test for association/independence was conducted between gender and the number of student who leave The College of Engineering after their first year, and between gender and first term success as defined in the "research question" section. All expected cell frequencies were greater than five. There were no statistically significant associations found in this analysis. Chi-Squared values for each research question respectively:

1. $\chi^2(1) = 3.34, p = .07$
2. $\chi^2(1) = 1.22, p = .27$

Because neither p-value was lower than the specified critical value, it means that there is no significant difference between the proportion of females leaving The College from what you'd expect based on the proportion of females in The College. Similarly there is not a significant different between the proportion of female students who have averages below 60% than you'd expect.



CONCLUSION

The results of this analysis suggest that there is little difference between male/female performance and commitment to The College, leaving the possible reasons for low female participation in engineering (at the U of S) unknown. Diversity is widely understood in industry to be valuable and necessary for innovation, and more effective workplaces; if engineering graduates from the U of S are to stay competitive, further discussions are needed around why female students are not entering The College.

"Diversity is essential to growth and prosperity... breeds innovation, and innovation breeds business success." ~ Ekaterina Walter

OPPORTUNITIES FOR FUTURE RESEARCH

If, as the data suggests, there is no significant difference between male and female engineering students at the university of Saskatchewan, there exists an opportunity to discover why there is such a difference in the enrollment of female and male students. It would also be beneficial to expand the analysis (for research question number 2 to more than a single cohort of students in order to know if females or males outperform one another academically.

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Gwenna Moss Centre For Teaching Effectiveness

University of Saskatchewan
College of Engineering

Appendix C – Full Survey Questions

Below is a table listing the questions asked of students in the Full Survey, listed by construct.

Measured Factor	Item Number	Question
To link to demographic data	1	Please enter your nsid (example: abc123)
Disappointment Threshold Delta	2	What grade point average do you hope to obtain in your first-year of engineering?
	3	What is your disappointment threshold?
Self-efficacy measure	4	I believe I will receive excellent grades in my upcoming year of university
	5	I'm certain I can understand the most difficult material presented in my classes
	6	I'm confident I can do an excellent job on the assignments and tests in my classes
	7	I expect to do well in my classes
	8	I'm confident I can understand the basic concepts taught in my classes
	9	I'm certain I can master the skills being taught in my classes
	10	Even if I have trouble learning the material in my classes, I try to do the work on my own, without help from anyone
	11	I ask my professors to clarify concepts I don't understand well
	12	When I can't understand the material in my classes, I ask another student in the class for help
	13	I try to identify students in my classes whom I can ask for help if necessary
12 Item Grit Scale - resilience	14	I have overcome setbacks to conquer an important challenge
	15	New ideas and projects sometimes distract me from previous ones
	16	My interests change from year to year
	17	Setbacks don't discourage me
	18	I have been obsessed with a certain idea or project for a short time but later lost interest
	19	I am a hard worker
	20	I often set a goal but later choose to pursue a different one
	21	I have difficulty maintaining my focus on projects that take more than a few months to complete
	22	I finish whatever I begin
	23	I have achieved a goal that took years of work
	24	I become interested in new pursuits every few months
	25	I am diligent
Academic Motivation Scale - measures extrinsic, intrinsic, amotivation and attitude	26	Because with only a high school degree I would not find a high paying job later on
	27	Because I enjoy myself when learning new things
	28	Because I think that a college education will help me better prepare for the career I have chosen
	29	For the satisfying feelings I experience when I am communicating my own ideas to others
	30	Honestly, I don't know; I really feel that I am wasting my time in school
	31	For the pleasure I experience while surpassing myself in my studies
	32	To prove to myself that I am capable of completing my college degree
	33	In order to obtain a more prestigious job later on

Measured Factor	Item Number	Question
	34	For the feeling I get when I discover new things that I've never seen before
	35	Because eventually it will enable me to enter the job market in a field that I like
	36	For the positive feelings that I have when I read about engineering topics
	37	I once had good reasons for going to college; however, now I wonder whether I should continue or not
	38	For the pleasure that I experience when I am surpassing myself in one of my personal accomplishments
	39	Because of the fact that when I succeed in college I feel important
	40	Because I want to have "the good life" later on
	41	For the pleasure that I experience in broadening my knowledge about subjects which appeal to me
	42	Because this will help me make a better choice regarding my career orientation
	43	For the pleasure that I experience when I feel completely absorbed by reading about the material we learn
	44	I can't see why I go to college and frankly, I couldn't care less
	45	For the satisfaction I feel when I am in the process of accomplishing difficult academic activities
	46	To show myself that I am an intelligent person
	47	In order to have a better salary later on
	48	Because my studies allow me to continue to learn about many things that interest me
	49	Because I believe that a few additional years of education will improve my competence as a worker
	50	For the "high" feeling that I experience while reading about various interesting subjects
	51	I don't know; I can't understand what I am doing in school
	52	Because college allows me to experience a personal satisfaction in my quest for excellence in my studies
	53	Because I want to show myself that I can succeed in my studies
Institutional climate	54	I am proud to say that I am an engineering student
	55	My professors want me to succeed in my classes
	56	First-year engineering is meant to "weed out" students
	73	I feel that first-year should weed out students that aren't ready
	60	The College of Engineering is a welcoming place
	79	I am happy with my choice to go into engineering
Curriculum	57	The material in my first-year classes is going to be very useful in my upper-year classes
	62	What I am learning in my classes will be useful in my chosen career
	63	I enjoy the material that we learn in our first-year courses
	64	I have no time for anything other than studying
	77	The first-year curriculum is too much work
	78	I find it easy to manage my classes along with my personal life
	80	The course material we learn in first-year is too hard
	81	I feel that I have enough time in a week to complete all of my assignments/tasks
	82	My instructors expect that we know more about a subject than we do coming into a class

Measured Factor	Item Number	Question
	83	I feel that I have learned enough in my previous classes in order to get by in my current classes
Peer influence/sense of belonging	58	I can see myself working as an engineer
	59	I feel as though I "fit in" in engineering
	68	I feel at home at the U of S
	69	I am similar to most other engineering students
	70	I have good friends who are also in engineering
	71	When I feel stressed out or overwhelmed by my classes, I know that other students are feeling the same
	74	I feel less stressed out than my peers
Faculty engagement	65	I feel comfortable seeking help from my professors
	66	My professors are willing to spend time with my outside of class
	67	If I pass my professors in the hallway, they will at the very least say hello
Mentorship/professional role modeling	72	I have people whom I consider mentors in engineering (professors, family, friends, etc)
	75	I consider my professors to be role models for me in my engineering career
	76	My professors are willing to spend time with me outside of class and help me understand the course material
This question is to see where the majority of students time is spent + how many hours per week they spend on studies. Factor = curriculum.	75	How many hours do you spend on assignments/quizzes/studying in the following classes per week: | Math 123
	76	How many hours do you spend on assignments/quizzes/studying in the following classes per week: | GE 101
	77	How many hours do you spend on assignments/quizzes/studying in the following classes per week: | GE 111
	78	How many hours do you spend on assignments/quizzes/studying in the following classes per week: | GE 124
	79	How many hours do you spend on assignments/quizzes/studying in the following classes per week: | COMM 102
	80	How many hours do you spend on assignments/quizzes/studying in the following classes per week: | CHEM 114
Open ended questions	90	What could the College do/change to make first-year more successful for engineering students?
	91	Are there any specific things that you can think of that act/acted as barriers to your success in engineering?
	92	Is there anything in your engineering degree so far that you feel is done well and helps students succeed?
	93	Is there anything else that you would like us to know about your first-year experience?

Appendix D – Individual and Focus Group Interview Guide

Hello/Introduction

Thank you. Explanation of the project and the project goals.

Consent form – ensure it is signed and that the participant understands all of its content.

Questions:

1. Can you tell me about your first semester experience?
2. Are you planning on continuing in engineering? Why or why not?
3. What do you feel are barriers to your success in engineering?
4. What things are done well in the first-year program?
5. What type of assistance could the College provide to help first-year students?
6. Why do you feel that students leave the College of Engineering?

Note: these questions were a guide and it was the student participant who led the discussion, within the context of these questions.

Appendix E – Data Variable Overview

The following table indicates data that was collected from historical College databases at the University of Saskatchewan campus for the past 10 years (n = 4680).

Variable	SPSS Identifier	Data Type
Attrition	Attrition_Numeric	Dichotomous
New direct entry vs transfer students	AdmitType	Nominal
Entrance average	Entrance_Ave	Continuous
Location listed on their application	From_Location	Nominal
Current registration status	Registered	Dichotomous
Cumulative degree average	Total_Degree_Ave	Continuous
Discipline	Major_Numeric	Nominal
Gender	Gender	Dichotomous
International/Domestic	Domestic_International	Dichotomous
Self identified Indigenous status	ANCESTRY	Dichotomous
HSENGLISH	HSENGLISH	Continuous
HSCHEM	HSCHEM	Continuous
HSPHYSICS	HSPHYSICS	Continuous
HSMATH	HSMATH	Continuous
Age of student	AGE	Continuous
Convocated or not	ConvoStatus	Dichotomous
Class used for the student's entrance average	EAClass1	Nominal
Class used for the student's entrance average	EAClass2	Nominal
Class used for the student's entrance average	EAClass3	Nominal
Class used for the student's entrance average	EAClass4	Nominal
Class used for the student's entrance average	EAClass5	Nominal
Class used for the student's entrance average	EAClass6	Nominal
Class used for the student's entrance average	EAClass7	Nominal
Term Averages:		
200509	200509 Average	Continuous
200601	200601 Average	Continuous
200609	200609 Average	Continuous
200701	200701 Average	Continuous
200709	200709 Average	Continuous
200801	200801 Average	Continuous
200809	200809 Average	Continuous
200901	200901 Average	Continuous
200909	200909 Average	Continuous
201001	201001 Average	Continuous
201009	201009 Average	Continuous
201101	201101 Average	Continuous
201109	201109 Average	Continuous
201201	201201 Average	Continuous
201209	201209 Average	Continuous
201301	201301 Average	Continuous
201309	201309 Average	Continuous
201401	201401 Average	Continuous
201409	201409 Average	Continuous
201501	201501 Average	Continuous

The following table is a listing of the variables and constructs that were collected from the full survey (n = 370, representing a 30% response rate from first-year students, and a 19% response rate from upper-year students).

Variable	SPSS Identifier	Data Type
Attrition	Attrition	Dichotomous
Faculty engagement construct	Faculty_Engagement_Construct	Ordinal/Continuous
Year in program	Year (1-4+)	Ordinal
Type of admission	Admit_Type	Nominal
Aboriginal ancestry or not	Ancestry	Dichotomous
Role model construct	Role_Models	Ordinal
Faculty mentorship construct	Faculty_Mentorship	Ordinal
Gender	Gender_Numeric	Dichotomous
High school attended prior to entering the college	HighSchool	Nominal
Discipline	Major_Numeric	Nominal
International student identifier	Domestic_International	Dichotomous
Cumulative degree average	TotalDegreeAve	Continuous
Entrance average	AdmitAvg	Continuous
High school english grade	HSENGLISH	Continuous
High school chemistry grade	HSCHE	Continuous
High school physics grade	HSPHY	Continuous
High school math grade	HSMATH	Continuous
Institutional climate construct	InstitutionalClimateScore	Ordinal/Continuous
Curriculum construct	Curriculum_Construct	Ordinal/Continuous
Resilience score	GritScore	Ordinal/Continuous
Self-efficacy score	SelfEfficacyScore	Ordinal/Continuous
Self-efficacy - dichotomous variable	High_SelfEfficacy	Nominal
Sense of belonging construct	SenseOfBelonging	Ordinal/Continuous
Defining what motivates our students using AMS-28 Motivational Constructs	Int_Mot_toknow	Ordinal/Continuous
	Int_Mot_accomplishment	Ordinal/Continuous
	Int_Mot_stimulation	Ordinal/Continuous
	Ext_Mot_identified	Ordinal/Continuous
	Ext_Mot_introjected	Ordinal/Continuous
	Ext_Mot_external	Ordinal/Continuous
	Amotivation	Continuous
Grade below which the students would be deeply disappointed	Disapointment_Threshold	Continuous
Expected or actual grade received (first-years vs upper-years)	Expectedoractual_grade	Continuous
Disappointment threshold delta	ThreshholdMinusReal	Continuous
Institutional Climate		
I am proud to say that I am an engineering student		Ordinal
My professors want me to succeed in my classes		Ordinal
First-year engineering is meant to "weed out" students		Ordinal
I feel that first-year should weed out students that aren't ready		Ordinal
I am just trying to get through first-year		Ordinal
The College of Engineering is a welcoming place		Ordinal
I am happy with my choice to go into engineering		Ordinal

Curriculum		
The material in my first-year classes is going to be very useful in my upper-year classes		Ordinal
What I am learning in my classes will be useful in my chosen career		Ordinal
I enjoy the material that we learn in our first-year courses		Ordinal
I have no time for anything other than studying		Ordinal
The first-year curriculum is too much work		Ordinal
I find it easy to manage my classes along with my personal life		Ordinal
The course material we learn in first-year is too hard		Ordinal
I feel that I have enough time in a week to complete all of my assignments/tasks		Ordinal
My instructors expect that we know more about a subject than we do coming into a class		Ordinal
I feel that I have learned enough in my previous classes in order to get by in my current classes		Ordinal
Peer Influence/Sense of Belonging		Ordinal
I can see myself working as an engineer		Ordinal
I feel as though I "fit in" in engineering		Ordinal
I feel at home at the U of S		Ordinal
I am similar to most other engineering students		Ordinal
I have good friends who are also in engineering		Ordinal
When I feel stressed out or overwhelmed by my classes, I know that other students are feeling the same		Ordinal
I feel less stressed out than my peers		Ordinal
Faculty Engagement		
I feel comfortable seeking help from my professors		Ordinal
My professors are willing to spend time with my outside of class		Ordinal
If I pass my professors in the hallway, they will at the very least say hello		Ordinal
Mentorship/Professional Role Modeling		
I have people whom I consider mentors in engineering (professors, family, friends, etc.)		Ordinal
I consider my professors to be role models for me in my engineering career		Ordinal
My professors are willing to spend time with me outside of class and help me understand the course material		Ordinal
Hours Spent on each class		
Math 123	1 to 10+ hours	Ordinal
GE 111	1 to 10+ hours	Ordinal
GE 124	1 to 10+ hours	Ordinal
COMM 102	1 to 10+ hours	Ordinal
CHEM 114	1 to 10+ hours	Ordinal

Qualitative data has been collected from the following sources:

Focus group

One focus group was conducted with five first-year students who were all in the top 5% of the first-year class in Fall of 2015.

Interviews

Five interviews were conducted with first-year students who were struggling and in the bottom 15% of their class in Fall of 2015. All of the students have subsequently stayed in the College.

Qualitative survey questions from the survey:

Qualitative Survey Questions	
What could the College do/change to make first-year more successful for engineering students?	Open ended
Are there any specific things that you can think of that act/acted as barriers to your success in engineering?	Open ended
Is there anything in your engineering degree so far that you feel is done well and helps students succeed?	Open ended
Is there anything else that you would like us to know about your first-year experience?	Open ended

Appendix F – Five-Year Graduation Snapshot

201209 to 201709 - Five-year graduation rate data (N = 468)				
Student Background	**n**	**Awarded and Engineering Degree**	**Still Enrolled in Engineering**	**Left the U of S**
Within SK - Rural	n = 109	39%	13%	28%
Within SK - Urban	n = 224	50%	18%	16%
Canadian - Outside of SK - Rural	n = 9	11%	11%	44%
Canadian - Outside of SK - Urban	n = 52	40%	21%	27%
Self Reported Declaration	**n**	**Awarded and Engineering Degree**	**Still Enrolled in Engineering**	**Left the U of S**
Self Reported Indigenous	n = 12	25%	25%	25%
Non-Indigenous	n = 456	46%	16%	23%
Gender	**n**	**Awarded and Engineering Degree**	**Still Enrolled in Engineering**	**Left the U of S**
Male	n = 377	40%	16%	25%
Female	n = 91	46%	19%	13%
Student Status	**n**	**Awarded and Engineering Degree**	**Still Enrolled in Engineering**	**Left the U of S**
Domestic	n = 418	46%	16%	21%
International	n = 50	36%	20%	36%
Age (beginning degree)	**n**	**Awarded and Engineering Degree**	**Still Enrolled in Engineering**	**Left the U of S**
≤18	n = 319	47%	15%	21%
19	n = 60	35%	22%	22%
20	n = 30	53%	20%	17%
21	n = 22	45%	14%	36%
22 to 25	n = 30	37%	17%	40%
26 to 29	n = 6	50%	0%	33%
30+	n/a	0%	0%	0%
High School Average	**n**	**Awarded and Engineering Degree**	**Still Enrolled in Engineering**	**Left the U of S**
95% to 100%	n = 85	61%	18%	8%
85% to 94%	n = 253	44%	17%	22%
75% to 84%	n = 71	35%	18%	31%
<75%	n = 7	29%	43%	14%
nan	52	42%	6%	40%

Appendix G – Descriptive Analysis of Full Survey

Descriptive analysis is included, indicating the poor fit of this data for inferential testing.

Variable	Data Set	Description	Data Type	Sample Size (If categorical, proportions)	Histogram Analysis / Outliers	Missing Values	Scale Analysis (cronbach alpha)	mean	mode	median	range	variance	standard deviation	skewness	kurtosis	homoscedasticity	Multi-collinearity
Survey Demographics: 40% first year, 19.5% second year, 23% third year, 17.5% fourth year			Categorical/Continuous				Continuous-->										
Grit	Survey	established scale	Ratio	350	no noticable outliers	15	0.75	3.48	3.25	3.5	3	0.26	0.5	-0.102, SE=.13	0.094	Not applicable for logistic regression	Highly related to intrinsic motivations, amotivation, self efficacy, and institutional climate
Self-efficacy	Survey	established scale	Ratio	365	no noticable outliers	0	0.93	3.44	3.8	3.5	3.7	0.34	0.58	-0.605, SE=.128	0.99	Not applicable for logistic regression	Highly related to everything except admittance average, extrinsic external motivation, Hsenglish, and workload
Sense of Belonging	Survey	Created scale, average of 4 questions	Ratio	333	4 participants noticably lower at a score of 1.2	32	0.77	3.77	3.6	3.8	3.8	0.61	0.78	-0.763, SE=.134	0.628	Not applicable for logistic regression	highly related to almost everything - see correlation matrix
Curriculum/ Workload	Survey	scale, average of 5 survey questions	Ratio	365	x	0	0.74	93.8	2.6	3.4	998	80908	284.4	2.86, SE=.128	6.26	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Instrinsic Motivation (to know)	Survey	AMS-established scale	Ratio	341	no noticable outliers	24	.83-.86	3.82	4	4	3.5	0.62	0.79	-.482, SE=.132	-0.042	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Instrinsic Motivation (accomplish ment)	Survey	AMS-established scale	Ratio	341	no noticable outliers	24	.83-.86	3.3	3	3.25	4	0.76	0.87	-.152, SE=.132	-0.33	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Instrinsic Motivation (stimulation)	Survey	AMS-established scale	Ratio	341	no noticable outliers	24	.83-.86	3.05	3.25	3	4	0.79	0.89	-.063, SE=.132	-0.28	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Extrinsic Motivation (identified)	Survey	AMS-established scale	Ratio	341	no noticable outliers	24	.83-.86	3.9	4	4	3.5	0.49	0.7	-.748, SE=.132	0.581	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Extrinsic Motivation (introjected)	Survey	AMS-established scale	Ratio	341	no noticable outliers	24	.83-.86	3.39	3.75	3.5	4	0.90	0.95	-.27, SE=.132	-0.359	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Extrinsic Motivation (external)	Survey	AMS-established scale	Ratio	341	no noticable outliers	24	.83-.86	3.58	4	3.75	4	0.96	0.98	-.593, SE=.132	-0.132	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.

Continued.

Variable	Data Set	Description	Data Type	Sample Size (If categorical, proportions)	Histogram Analysis / Outliers	Missing Values	Scale Analysis (cronbach alpha)	mean	mode	median	range	variance	standard deviation	skewness	kurtosis	homoscedasticity	Multi-collinearity
Survey Demographics: 40% first year, 19.5% second year, 23% third year, 17.5% fourth year			Categorical/Continuous				Continuous-->										
Amotivation	Survey	AMS-established scale	Ratio	341	no noticable outliers	24	.83-.86	1.48	1	1.25	4	0.50	0.71	1.799, SE=.132	2.987	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Perception of Faculty	Survey	created scale, average of xx questions	Ratio	333	no noticable outliers	32	0.74	2.97	2.67	3	4.67	0.93	0.962	.077, SE=.134	-0.333	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Mentorship	Survey	asked question directly	Ratio	323	no noticable outliers	42	x	3.03					1.37			Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Institutional Climate	Survey	created scale, average of xx questions	Ratio	333	no noticable outliers	32	0.73	3.97	4.25	4	4	0.53	0.729	-1.04, SE=.134	1.196	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Entrance Average	Survey	total of 5 classes, varying by student	Ratio	363	no noticable outliers	2	x	89.28	93	91.4	31	49.97	7.07	-.998, SE=.128	0.313	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Gender	Survey	male, female	Nominal	365	26.3% female (compared to 19% females in the college)	0	x	x	x	x	x	x	x	x	x	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Aboriginal Ancestry	Survey	self identified, verified, non-aboriginal	Nominal	365	96.7% non-aboriginal (comparitive to 3% self reported aboriginal in the college)	0	x	x	x	x	x	x	x	x	x	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
International Student Status	Survey	domestic, international	Nominal	365	93.4% domestic	0	x	x	x	x	x	x	x	x	x	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Attrition/retention	Historical	Binary variable; 0=attrition, 1=retention, 999=current student or unknown	Ordinal	3700	36.7% attrition, 25.9% convocated, 37.4% current	2215	x	x	x	x	x	x	x	x	x	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
Entrance Average	Historical	total of 5 classes, varying by student	Ratio	4069	no noticable outliers	1846	x	87.39	90	89	53.4	59.74	7.73	-1.012, SE=.038	0.946	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
High School Math Grade	Historical	collinearity exists between HS grades and the entrance average	Ratio	5122	no noticable outliers	793	x	85.99	84	87.33	56.8	75.03	8.66	-.847, SE=0.034	0.67	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
High School Physics Grade	Historical	collinearity exists between HS grades and the entrance average	Ratio	5080	no noticable outliers	835	x	85.55	90	87	90	74.58	8.64	-1.07, SE=0.034	2.29	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.
High School English Grade	Historical	collinearity exists between HS grades and the entrance average	Ratio	5092	no noticable outliers	823	x	82.6	80	84	75.33	78.04	8.83	-.92, SE=0.034	1.32	Not applicable for logistic regression	Each construct was significantly related to many other factors, therefore disrupting the use of multiple regression.

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