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Persistence of Engineering Undergraduates at a Public Research University

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PERSISTENCE OF ENGINEERING UNDERGRADUATES AT A PUBLIC RESEARCH UNIVERSITY

by

Matthew Meyer

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ABSTRACT

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Descriptive and inferential statistical analysis of the institutional data collected on engineering undergraduate students uncovered several factors predictive of persistence/ nonpersistence. These include projected age at graduation, high school GPA and ACT scores, residency status, scholarship, and financial aid.

Common themes for ten students who dropped out of engineering included individual factors such as poor academic performance, feeling unprepared for demands of the engineering program, difficulty fitting into engineering, and institutional factors such as disappointment with engineering advising. New concepts uncovered in this paper, which were not prevalent in existing research, include a deeply emotional attachment between participants and the concept of being an engineer, a deeper understanding of student's sense of loss and failure, and their easy transition from engineering to another major.

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I wish to thank a number of people who have made this study possible. I first recognize the participants of this study. Their willingness to be interviewed and to be frank in their comments and feedback is much appreciated. This study stirred up some unpleasant memories for the participants. That was not my intent but I recognize that some of the wounds of the past were deeper than I realized. Their future looks optimistic though, and I wish them all the best.

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Of course, I am extremely grateful to my wife, Michelle, and our children for their encouragement and support. I did my best to balance my life, work, and studies. I tried not to miss opportunities to be with family. Still, there were many Saturdays when I abandoned the family to lock myself in my office. My wife’s patience is extraordinary and I could not have completed the program without her love and support.

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CHAPTER I

INTRODUCTION

In March 2006, a hearing was held before the subcommittee on research in the U.S. House of Representatives concerning best practices in undergraduate math, science, and engineering education (House Committee on Science, 2006). Five experts in the field of undergraduate education relayed their experience with a critical problem facing science, technology, engineering, and mathematics (STEM) educators which is persistence of qualified students. Dr. Carl Wieman testified, “Science majors are not being created in college. Rather, they are primarily the few students that, because of some unusual predisposition rather than ability, manage to survive their undergraduate science instruction” (House Committee on Science, 2006, p. 47). Many capable students avoid STEM education or drop out of STEM programs in college. Seymour and Hewitt (1997) found that 44.1% of STEM majors switched to non-STEM majors before graduation.

There exists a great deal of research on persistence of undergraduate students in general and STEM undergraduates in particular (Eris et al., 2010). The most prevalent reasons cited in the literature for low-persistence rates for STEM majors include lack of K-12 preparation for the rigor of STEM education, poor teaching and counseling, and difficulty students experience in adapting to the educational and social demands of STEM programs (Duncan & Zeng, 2005; Godfrey, Aubrey, & King, 2010; Haag, Hubele, Garcia, & McBeath, 2007; Lowery, 2010; Schmidt, Hardinge, & Rokutani, 2012). Persistence studies have been done using quantitative, qualitative and mixed-methodological forms of inquiry (Borrego, Douglas, & Amelink, 2009). Quantitative studies have been useful in determining what factors lead to persistence/nonpersistence in STEM programs, determining rates of attrition, and assessing intervention strategies to improve persistence (Hurtado, Eagan, & Chang, 2010). Qualitative studies delve into the reasons why students leave. These include factors mostly under the control of the student, “individual factors” such as academic performance, financial pressures, and motivation (Cabrera, Nora, & Castaneda, 1992). Other qualitative studies have investigated factors mostly under the control of learning institutions, “institutional factors” such as advising and faculty support (Sutton & Sankar, 2011). Mixed-methodological studies offer a combination of favorable aspects of quantitative and qualitative inquiry (Johnson, 2012).

This mixed-methodological study attempted to gain an understanding of persistence of engineering undergraduates at one major western research university. Data had been collected by a major western research university on engineering majors from 2006 to 2013 that described the students entering the engineering program and documented their high school performance. These data were separated into groups of engineering students who persisted to the junior year of their undergraduate engineering program (persisters), and those students who left their engineering program before their junior year (nonpersisters). A quantitative analysis comparing these two groups of students uncovered significant predictors of persistence/nonpersistence in the engineering program. Qualitative inquiry was used to identify factors leading to nonpersistence from the perspective of ten nonpersisting student volunteers from the institutional data population. Together, the quantitative and qualitative methods of inquiry formed a mixed-methodological study that provided a vivid picture of the challenges facing a major western research university regarding persistence of engineering undergraduates.

Although significant research has been done to determine the major causes of low persistence for STEM majors in general and engineering majors in particular, the relevance of this research varies for each university. This is due to differences in culture for each university. Using a mixed-methodological approach, this study combines the resources of institutional data with qualitative data from the students themselves to paint a rich and full picture of the experience students encounter at a major western research university. Understanding the student experience can help determine which findings from the literature apply to this university. From this the focus of changes required for the university to increase the persistence of its engineering students can be narrowed.

Rationale and Purpose of the Study

Low engineering student persistence rates are a significant and growing problem for universities across the U.S. (Lowery, 2010). The U.S. Bureau of Labor Statistics (2007) reported that occupations in STEM are expected to grow by 22% between the years 2004 and 2014 while all other occupations average 13% growth. Because engineering jobs are increasing and engineering graduates are decreasing, an emphasis has been placed on engineering educators to graduate more engineers.

Politicians, educators, and employers are aware of the shortage of engineers, and have implemented programs to interest more freshman university students in engineering. Persistence rates among engineering freshman continue, however, to be very low. University administrators must understand the specific circumstances contributing to low persistence of engineering students, and implement appropriate changes to their programs. The purpose of this study is to explore factors that may predict the likelihood of success for students in the engineering program of one western university, and to understand challenges faced by ten nonpersisting students in their engineering education. Using mixed-methodological inquiry, this study investigated institutional and individual factors contributing to students' likelihood of persisting through their Junior year of the undergraduate engineering education at a major western research university. Additionally, ten of the students who left engineering were interviewed to understand their perspective on why they left the engineering undergraduate program. Information discovered in this study can help administrators at a major western research university to target effective changes to increase persistence rates for engineering students.

Research Questions

The following questions framed this investigation.

1. Which factors are associated with persistence in engineering?

2. From the perceptions of ten nonpersistent engineering students, why did they leave the engineering college at a major western research university?

Definition of Key Terms

The following terms will be defined as follows for the purposes of this study.

Academic years: A major western research university had been on a semester system over the data collection period. An academic year would start with a fall semester followed by spring semester and finally a summer semester.

Institutional data: The institutional data was collected by a major western research university from academic years 2005 to 2013. Data for 2006 through 2013 was obtained from the Banner system. Data before 2006 was problematic and incomplete and was not considered in this study. Data included demographic descriptors, high school and college academic performance measures, socioeconomic status, and residence.

Independent variables: The following variables were extracted or calculated from institutional data: gender, marital status, birthdate, projected graduation date, projected age of student at graduation, residency status, transfer or first year students, high school GPA, math ACT, composite ACT, SOAR participation, scholarship recipient, financial aid, lived on campus, and served missions for The Church of Jesus Christ of Latter-day Saints (LDS). Because the validity of the conclusions obtained from this study is dependent on the institutional data collected, it is important to clarify the definition of each of the independent variables. Each of these variables are defined below.

Gender: Gender was reported as M for male and F for female. There were no other categories.

Marital Status: Marital status was reported as M for married, S for single, and D for divorced. It should be noted that the date or scholastic year at which marital status was reported was not included. There may have been students whose marital status changed after it was reported to the Banner system. Also, marital status for students may have been different when non-persisters made the decision to leave engineering.

Birthdate: Birthdates were reported with day, month, and year at birth. Because engineering undergraduates enter, leave and graduate from engineering programs at various ages, the combination of Birthdate and Projected Graduation Date were used to create an independent variable called Projected Age at Graduation. This variable was used to analyze the effects of age on student persistence.

Residency Status: Residency status was reported as R for resident, N for nonresident, and I for international. Resident means the student has established residency in the State containing a major western research university. Nonresident applies to students having residency in other States in the United States. International student have residency outside of the United States.

Transfer or First Year Students: Transfer students were identified by naming the institution they attended before transferring to a major western research university. First year students were identified as FFT (first year full time students). Data in this category were incomplete and difficult to understand. It was unclear which institution students transferred from because different nomenclature was used for different students. High school students with concurrent enrollment from another institution may also have qualified as transfer students. Many students had several institutions listed and no information was available to determine how much time the student had spent at each institution.

High School Grade Point Average (GPA): High School GPA was reported numerically with a range of 0 – 4. Some limited data was contained in the institutional data on student performance (grades) at a major western research university. These data were incomplete and difficult to use to draw any meaningful comparisons between persisters and nonpersisters. For this reason, college performance was not used in this study.

Math ACT Score; Comp ACT Score: Admission requirements to a major western research university include the American College Test (ACT) which has a math component (Math ACT) and a composite score (Comp ACT). Both scores have a range of 0 - 36.

SOAR Participation: The major western university has a Student Orientation, Advising, and Registration (SOAR) program for incoming freshmen. Participation in SOAR was reported as Y for yes and N for no. Very few of the students participated in SOAR because the students either came in as non-freshmen or were not required at the time to participate in SOAR.

Scholarship: Scholarship was reported as Y for the students who received a scholarship from a major western research university, or N for the students who had not received a scholarship from a major western research university. Information on the type or amount of scholarship was unavailable. Scholarships from private sources were also not reported.

Financial Aid: Students who had received financial aid from one a major western research university's sources were reported as Y. Students who had not received financial aid from a major western research university were reported as N. Information on the timing or amount of financial aid was not available.

Lived on Campus: If the student had ever lived at a major western research university's on-campus housing, it was reported as Y. For students who had never lived in on-campus housing, it was reported as N. No information on how long or when the student lived in on campus housing was available.

Served LDS Mission: Students from the population who had served a mission for the Church of Jesus Christ of Latter Day Saints were reported as Y. All other students were reported as N. The reported number of students who had served LDS Missions seemed low. Personnel from the data recording office at a major western research university reported that these data are questionable because student participation in religious activities is often not reported.

Population: The population extracted from the institutional data included all students who have registered for any pre-professional engineering program at a major western research university during the period of data collection (2006-2013).

Preprofessional program: The first 2 years of instruction for engineering students used as preparation for the professional program.

Professional program: The final 2 years of engineering instruction culminating in a bachelor's degree in one of the following disciplines: civil and environmental engineering, mechanical engineering, electrical engineering, biological engineering, and computer engineering.

Persisters: The 383 students with the latest projected graduation dates from the population who have been accepted to one of the engineering professional programs. Specifically, those students who had successfully completed a 3000 level (i.e. Junior level) engineering course were defined as persisters, as a major western research university has a policy of not allowing students to take a 3000-level engineering course without first being accepted into one of the engineering professional programs.

Nonpersisters: Students from the population who left engineering before entering the professional program. Nonpersisters are identified by the 383 records kept by a major western research university of those students who changed their major from engineering from 2011 to 2014.

Scope and Limitations of the Study

Scope of the Study

The scope of this mixed-methodological study was to determine which factors contributed to undergraduate student attrition through quantitative analysis of institutional data, and to evaluate reasons ten undergraduate engineering students failed to complete their engineering degree at a major western research university utilizing qualitative techniques of inquiry. The scope of this study does not include any attempt to quantify the persistence rate of the engineering college at a major western research university.

Quantitative Limitations

Quantitative data used in this study are limited by the quality of the institutional data managed by the subject institution, and are representative only of the subject research population. Many of the limitations of these data are identified in the definitions section. Conclusions based on data analyzed for the effect of marital status, projected age at graduation, residency status, and financial aid on persistence were qualified based on limitations of the data discussed above. Conclusions based on transfer students, SOAR participation, scholarship recipient, on campus housing, and LDS mission service were removed due to data reliability concerns as described in the definitions section. Generalizability of the conclusions of this study is limited because the data were collected from only one major western research university.

Qualitative Limitations

As with most qualitative studies, the small sample size allowed the researcher to dive deeply into the experience of the participant, but limits the ability to generalize results to other populations. Only ten people committed themselves to sharing their experiences leaving engineering. Although participants offered rich insights into their experiences, they do not necessarily represent the experiences of other students at a major western research university, or the broader group of engineering students in general. Although similarities and common themes were apparent in the participants' stories, it is likely that a larger sample size would have uncovered additional reasons students leave engineering at a major western research university. Also, despite the researcher's best efforts, the researcher's background as an engineering graduate necessarily influenced interpretation of the participants' stories. The researcher could relate to their stories as they told them from the researcher's similar experience. Of course, this limitation also gave the researcher greater insight into a major western research university's engineering program that allowed better understanding of its complexity.

It is also recognized that some of the ten participants, having recently left a major western research university's engineering college, harbored negative feelings toward the college. The first attempt to secure volunteers to participate in the study involved sending a solicitory email to the 18 students who had left engineering during the semester the study was initiated. No responses were received. When an email was sent to the other 365 students who had left the engineering college at a major western research university since 2011, very few responded. The first ten respondents were selected as participants in the qualitative portion of the mixed-methodological study. The motivations of the respondents for participating in the study were not explored. The researcher was careful to relay the participants' experiences as engineering undergraduates with minimal guidance and correction. Thus, the participants were free to tell their version of the story. As recent drop outs from the engineering college, the participants were, necessarily, biased. Some of their bias is apparent because of inconsistencies in describing their experiences. In relaying the participant's stories, the researcher made no attempt to correct, or justify statements made by the participants.

CHAPTER II

REVIEW OF THE LITERATURE

The U.S. is losing its long-held superiority in innovation. A number of measures indicate the weakening of the engineering profession in relation to developing countries such as India, Russia, and China (Akay, 2008; Savitz, 2011; Wadhwa, Gereffi, Rissing, & Ong, 2012). In 2009, for the first time more than half of U.S. patents were awarded to non-U.S. companies (Savitz, 2011). China has replaced the U.S. as the number one exporter of technology. Many point to the failings of the U.S. educational system as the primary reason for this disturbing trend (Manger, 2000; Trigwell, Prosser, & Taylor, 1994). In 2011, the World Economic Forum ranked the U.S. as 48th out of 133 countries in the quality of math and science instruction (Savitz, 2011). Akay (2003) highlighted a symbiotic relationship between engineering education and technical superiority.

In an effort to stem the decline of engineering in the U.S., much effort has been focused on improving the number and diversity of engineering graduates (Akay, 2003). Focus on STEM career preparation has been a very popular topic over the past few years (Tseng, Chen, & Sheppard, 2011). In his 2013 inaugural address, President Obama joined in the call for thousands of new engineering graduates to strengthen the global status of the U.S. in innovation. The research has shown that this effort has yielded mixed results (Hsieh, 2012; Tseng et al., 2011). Although millions of dollars have been invested to grow interest in STEM for high school, middle school, and even elementary students, the decline of engineering graduates, in comparison with some developing countries, continues. In his 2006 testimony before the U.S. House Subcommittee on Research, Dr.

Carl Wieman, a distinguished physicist and educator stated, “Unless we improve STEM education at the college level first, we are wasting our time and money on making major improvements in K-12” (p. 49). He further argued that engineering education at the university level was “based on an outdated model” and required a major overhaul before it could accommodate increased interest in engineering education (House Committee on Science, 2006, pp. 48-51).

Herzog (2006) argued that determining why students drop out is less important than being able to predict why students transfer out. Much research, both quantitative and qualitative, has been conducted to determine what factors or characteristics are predictive of success in completing undergraduate engineering programs (Caroni, 2011; Duncan & Zeng, 2005; Morganson, 2010; Schmidt et al., 2012; Suresh, 2007). The results of these studies have been mixed. It has been reported that SAT and ACT test scores are indicative of students’ success. Students with higher scores, especially in the mathematics sections of the standardized tests, have been shown to persist in engineering programs at a higher rate than students with lower test scores (Seymour & Hewitt, 1997; Ureksoy, 2011). Similar relationships have been shown for students with higher grades in high school, although this relationship is harder to define with widely varying instruction and grading structures in the high schools from which these students are drawn (Hartman & Hartman, 2006).

Less significant factors shown to affect persistence include gender, race, ethnicity, and employment (Amelink & Meszaros, 2011; Tyson, 2012). Qualitative studies have attempted to show a relationship between the culture of various universities and their effect on persistence of engineering undergraduates (Trigwell et al., 1994). These studies have shown dissatisfaction with many aspects of undergraduate engineering education. Students have criticized faculty for poor teaching and mentoring, and for creating an ultra-competitive, weed-out culture (Seymour & Hewitt, 1997). Engineering faculty has criticized students for lack of commitment, poor preparation, a lack of focus, and poor study habits (Tyson, 2012). Employers have criticized both engineering faculty and students for the lack of preparation exhibited by engineering graduates in the workforce (Austin, Connolly, & Colbeck, 2008; Newswander & Borrego, 2009; Nyquist et al., 1999).

Clearly, there is much room for improvement in many areas of engineering education. This does not, however, explain why persistence of engineering undergraduates is so low, as all students, both persisters and nonpersisters, are subject to the same educational experience. Understanding the reasons students leave engineering is key to improving all levels of engineering education in an effort to increase persistence (Seymour & Hewitt, 1997).

This review of the literature is divided into four major sections. The first section is a review of research done on persistence and graduation rates for undergraduate students. The second focuses on literature dealing with STEM students in general and engineering undergraduate students in particular. The third section discusses how this research work contributes to the existing literature. The fourth section discusses mixed methodological research.

Studies of Undergraduate Persistence and Dropout Rates

Much of the groundwork on persistence of undergraduates was completed in the early 1970s by Rootman (1972), Spady (1970, 1971), and Tinto (1975). Based on concepts borrowed from Durkheim’s theory of suicide, Tinto postulated that one reason students withdrew from college was failure to integrate into the social system of a college program (Tinto, 1975). Tinto (1982) felt the student and the university both played a key role in student integration and persistence. He emphasized the role of the university in understanding the effect of the student integration process, and utilizing this understanding in changing policies and procedures to increase persistence of capable students.

Tinto (1998) later identified two key factors in determining a student’s likelihood of persisting. These were student commitment and institutional commitment. Student commitment is a measure of the student’s integration into the educational community, and could be measured by academic performance, participation in academic clubs, relevant work-study programs, and so forth. Institutional commitment is a broad measure of the institution’s desire to help the student succeed. This desire is made manifest through positive interaction between faculty, advisors, and students. Of the two key factors, Tinto felt the student commitment to be the most important factor in student persistence.

Many researchers have disagreed with Tinto’s assertion that student commitment is key in determining the likelihood of persistence. Pascarella and Terenzini (1983) showed that gender differences weakened Tinto’s student persistence model. Female students seemed to place more weight on social integration than male students. Male students valued academic integration much higher than social integration. Bean (1985) developed an alternative model of student attrition based on factors such as students' intent to drop out of their college programs. He found that males and females dropped out of school for different reasons but both males and females found that institutional commitment was an important factor in their decision. Researchers have linked financial support to persistence rates claiming that lack of financial backing and increasing financial pressures lead to higher rates of attrition (Alon, 2005; Alon & Tienda, 2005; Cabrera et al., 1992; Chen & DesJardins, 2008; DesJardins, 2001). Cabrera, Nora, and Castaneda (1993) found that sufficient financial backing helped students integrate more readily because these students could participate in extracurricular activities and socialize with their classmates. Encouragement and commitment from significant others was also found to be helpful in increasing persistence.

Although the methods and models used by researchers vary widely, most generally share the finding that students who feel comfortable and accepted have lower rates of attrition. Bean (1980) linked attrition of undergraduates to models used to predict turnover in work organizations. He concluded that the reasons employees left employment were similar to the reasons undergraduates left college. These include dissatisfaction with compensation, lack of recognition, and lack of interest and commitment to the work. Although college students do not receive compensation for their work, financial considerations and payback are very real factors in the student's decision to persist or to drop out. Lack of recognition could be compared to the attention and encouragement given to the student by faculty of advising staff. Lack of commitment and interest are directly comparable to student concerns. Based on existing models developed for employee persistence, Bean developed a model for student persistence. This model was built upon variables including student background, which provided an important view into the student's interest and commitment, and organizational determinants, which provided a measure of institutional commitment (Bean, 1980).

Literature dealing with overall factors contributing to student persistence in college can be broken into two areas of focus. The first is the student's educational commitment. This category includes the individual student's background, work ethic, and educational goals. Measurement of the student's educational commitment is primarily accomplished by grades earned in relevant courses. The second important category is institutional commitment. This includes the commitment the institution makes to student success, and is made manifest by healthy teacher-student interaction, positive advising, tutoring and mentoring, and strong extracurricular involvement opportunities.

Studies of STEM and Engineering Undergraduate Persistence

Friedman (2005, p. 253) used the term "a quiet crisis" to describe the failure of U.S. institutions to prepare sufficient scientists and engineers to compete in the global, high technology arena. Many researchers have studied the high attrition rates of engineering students and have found mixed results. Some findings apply globally to institutions and some apply only to specific universities. The reasons behind low student persistence and proposed solutions are complex. The bulk of the literature deals with diagnosing the reasons students leave STEM courses of study. Some literature exists on program changes that have increased student persistence at individual institutions. Most, however, have limitations on the generalizability of the causes of high persistence and the recommended solutions. This section provides a review of the literature relevant to undergraduate persistence issues for STEM majors in general and engineering majors in particular. It is divided into research into individual factors and institutional factors.

Research on Individual Factors

In a qualitative study of students who left university majors in the sciences, Seymour and Hewitt (1997) found that the majority of students left because of disinterest or disappointment in the field, or poor performance and loss of self-efficacy. The reasons students would lose interest or become disappointed in engineering are very complex, as are the explanations of poor performance. Tseng et al. (2011) reported that the level of student preparedness for the rigors of a university engineering program was very important in determining the chances of student success in the program. Zhang, et. al (2004) found that higher high school grades and SAT scores predicted higher persistence rates. The effect of other factors on persistence such as gender, race, SAT scores, and citizenship varied by institution. Traditionally, the answer to improving student preparedness has been to strengthen math and science education in high schools. Croft and Grove (2006) found, however, that good achievement in high school math and science courses is no longer a guarantee of success in first-year engineering courses.

This is due to the widely varying standards of achievement utilized by high schools, and the quality of education gained there. Adequate preparation for the first year of a university engineering course of study is very difficult to quantify let alone achieve. Bao, Edwards, Koenig, & Schen, (2012) reported that roughly 32% of the 1,830 students taking introductory biology, chemistry, and physics courses earned a D, F, or W, and were forced to retake the courses. Seymour and Hewitt (1997) found that 40% of STEM majors complained of inadequate preparation in high school.

In her 2006 testimony before the U.S. House of Congress Subcommittee on Research, Seymour called for improvements in the preparation of K-12 science and math teachers. This pervasive problem involves how future educators are taught and motivated. In her research, Seymour found that college professors and advisors were actively discouraging math and science majors from teaching careers, even “defining teaching ambitions as deviant” (House Committee on Science, 2006, p. 16). Good math and science teachers in high school not only help prepare students academically, but also instill motivation and excitement for careers in science and engineering. She concluded that if changes were not made, and teaching K-12 math and science remained undervalued, there is little hope in improving production and retention of STEM graduates. In a recent longitudinal study of persisting and nonpersisting engineering students, one significant difference between the groups was precollege influences and confidence in math and science skills (Eris et al., 2010). Thus, precollege educational and motivational preparation seems to play an important role in predicting success in college engineering.

Haemmerlie and Montgomery (2012) found models used to predict attrition for undergraduate engineering majors lacked detail explaining gender differences. Using the Hogan Personality Inventory (Hogan, 2007) they postulated that female engineering students displayed more commitment to the engineering field than their male counterparts, perhaps because the female students were in the minority. Factors traditionally used to predict persistence in college are, therefore, not as accurate with female students. In a longitudinal study conducted by Marra, Rogers, Shen, and Bogue (2012), however, no significant differences were found when analyzing various factors predicative of persistence. Other research has indicated that although the persistence rates remains similar for male and female students the reasons behind their respective persistence rates differs (Amelink & Meszaros, 2011; Duncan & Zeng, 2005). These differences were attributed to the female students valuing social acceptance more than their male counterparts (Duncan & Zeng, 2005). Marra et al. also found some slight differences in factors affecting persistence for minority students, but these were small compared to the major factors cited by students as reasons for their departure from engineering.

Tseng et al. (2011) found a sharp decrease in motivation to study engineering after the first year of undergraduate coursework. This supports Seymour and Hewitt’s (1997) findings that disappointment with the engineering field is a major factor leading to student’s switching majors. Feeling overwhelmed by the course material and other pressures, some students lost sight of the goal of pursuing an engineering degree. Many students attribute this loss of interest or disappointment to inadequate high school preparation. Tseng et al. (2011) saw this inadequate preparation not only in high school math and science material, but also in a lack of explanation of the engineering field. Bao et al. (2012) found that student's perceptions of introductory engineering courses, and the time commitment required to pass these courses, were often wrong and led to attrition. Misperceptions of the engineering field among freshman students plays a key role in persistence of these students (Prieto et al., 2009). Tseng et al. (2011, p. 1) suggested that while nonpersisters and persisters may take the same courses, they are "experiencing them in a very different way."

Financial concerns play an interesting role in engineering persistence. Engineering salaries and job potential continue to grow at a much higher rate than other professions according to the U.S. Bureau of Labor. Santovec (2004) found, however, that intention of high school students to pursue an engineering career had decreased by 35% in the past ten years. In a study on the effect of outside employment for engineering students, Tyson (2012) concluded that many engineers seek outside employment because scholarships often do not meet their financial obligations. Unfortunately, those working more than 20 hours per week off-campus are at a higher danger of dropping out. This supports conclusions reached by Bean (1980), who theorized that student persistence parallels employee persistence in the workplace. Students and employees often bow to short term financial pressures at the expense of their long-term goals.

Research on Institutional Factors

Seymour and Hewitt (1997) marked disappointment with engineering as one of the major factors leading students to drop out. Other researchers have reached similar conclusions, attributing this disappointment to poor teaching and mentoring (Marra et al., 2012; Nyquist et al., 1999), inadequate advising (Prieto et al., 2009; Schmidt et al., 2012), and an unwelcoming culture in the engineering college (Duncan & Zeng, 2005). Research has shown most that engineering students leave engineering do so because of perceived shortcomings in one of the following four areas: (a) academic and career counseling, (b) faculty, (c) engineering structure and curriculum, and (d) high school preparation (Haag et al., 2007, p. 929). Because the engineering institution has direct control over three of these reasons, it is important that universities understand causes of student attrition. This section explores the literature on factors under the control of the university that affect student persistence. Best practices for improving student persistence in engineering programs, as recorded in the literature, are also reviewed.

Engineering programs are normally taught sequentially, meaning courses must be taken in a predetermined sequence. Academic advising to guide students through the proper sequence of classes is very important to student success. Haag et al. (2007) found that students often complain of misinformation from engineering advisors that increased the time taken to graduate. van den Bogaard (2012) has shown that engineering students not only drop out at a rate higher than other majors, but also take longer to graduate. Faulty academic advising through complicated courses of study may contribute to longer graduation times. Another role the engineering advisor plays is that of career counselor. Research has shown that academic advising plays an indirect, but important role in student persistence. Quality advising can contribute to increased student satisfaction, higher grades, and fewer intentions to leave the university (Metzner, 1989). Woolston

(2002) found that although advising was important, reported student satisfaction was low. This is supported by Haag et al. (2007), who found that 53% of all engineering students were dissatisfied by the quality of academic advising. Specifically, students felt the information provided by advisors on course requirements was inaccurate, advisors did not make students aware of programs for help on coursework and financial aid, and students were not informed of career opportunities. McCuen, Gulsah, Gifford, and Srikantaiah (2009) found that students did not feel they were afforded sufficient time with advisors and advisors were too busy to help them. Other researchers found that a positive relationship between students and advisors proved beneficial in increasing persistence, but also eased the transition for students leaving engineering (Tseng et al., 2011).

Research has shown the student professor relationship to also be vital in promoting the success of engineering students (Hurtado et al., 2010; Prieto et al., 2009). Bradburn and Hurst (2001) showed that engineering students value the quality of engineering instruction less than individuals pursuing other majors. Tyson (2012) stated, “Engineering graduates value the degree but not the instruction, suggesting some tension between the students and faculty” (p. 482). According to Tinto (2006), the link between faculty development and student persistence has not been fully established. This is supported by Nyquist et al. (1999), who found that developing faculty to be more effective teachers often took a back seat to research. As a result, the quality of the teaching suffers and students leave engineering. Seymour testified (House Committee on Science, 2006, p. 15), “The quality of undergraduate STEM education has declined and is declining." One of the reasons she posed for this was the lack of professional teaching development for university faculty as well as pre-university math and science teachers.

Many researchers into persistence of engineering students are advocates of an introductory course for freshman engineering students (Bao et al., 2012; Tseng et al., 2011). Engineering seminars are designed to serve multiple purposes including informing incoming freshman of the commitment required to successfully complete an engineering major, kick-starting beneficial social interaction, and establishing a standard of math and science competency for beginning engineering students. Longitudinal studies have shown a positive response to freshman engineering seminar courses on the persistence of engineering students (Marra et al., 2012).

Mixed-Methodological Study of STEM Persistence

Mixed-methodological inquiry has emerged as the third methodological movement behind the traditional quantitative method and qualitative inquiry (Borrego et al., 2009). Mixed-methods study was described by Creswell, Plano Clark, Gutmann, and Hanson. (2002) as follows:

> A mixed methods study involves the collection or analysis of both quantitative and/or qualitative data in a single study in which the data are collected concurrently or sequentially, are given a priority, and involve the integration of the data at one or more stages in the process of research. (p. 212)

Although mixed-methodological studies are fairly rare in the fields of engineering education and student persistence, there are several examples of recent literature utilizing mixed methods (Gall, Knight, Carlson, & Sullivan, 2003; Hackett & Martin, 1998; Olds & Miller, 2004). Mixed-methodological studies using explanatory design utilize a qualitative research component to compliment the quantitative results. In their mixed-methodological study, Gall et al. (2003, p. 340) described their use of qualitative inquiry to add depth to their quantitative results saying, “As a complement to the statistical FCQ analysis, two midsemester classroom interviews were conducted.” Hackett and Martin (1988, p. 87) wrote, “Open-ended comments were analyzed as a qualitative component to shed light on numerical results.” Thus mixed-methodological inquiry in an explanatory design can be used to highlight relationships between quantitative and qualitative results, thereby offering a deeper and richer understanding of the results (Harwell, 2011).

Significance of This Study to the Literature

Significant research has been done on the reasons undergraduates leave engineering. As this review of literature shows, however, the vast majority of the literature has been quantitative in nature and does not lend sufficient credence to the voices of students who have left engineering. We are missing a deeper understanding of the reasons and justifications for leaving engineering that can be gained through mixed-methodological inquiry, which is the combination of quantitative and qualitative inquiry. Some important factors affecting persistence vary by university, which shows the need for university-specific studies. Each university must be aware of its own circumstances that contribute to student attrition. Understanding which institutional factors predict success in engineering for each individual school allows the university to focus its recruiting and admission efforts on those students most likely to persist. This is an effective and early way to increase persistence rates (Bean, 1980). Further, understanding the barriers to success faced by engineering students allows administrators to select students less likely to be affected by those barriers, more effectively prepare incoming students to face likely challenges, and alter programs to eliminate unnecessary barriers. Finally, the opinions and advice of nonpersisting students for future students and faculty is important in defining target areas for improvement and has not been fully addressed in the literature. This research project adds to the literature in these three vital areas.

CHAPTER III

METHODS

This embedded design mixed-methodological research is divided into three distinct components. The first is a quantitative analysis of institutional data collected on engineering undergraduates at a major western research university from academic year 2006-2007 to 2012-2013. Statistically significant factors contributing to persistence/ nonpersistence in the engineering undergraduate program were identified and described. Secondly, qualitative methods of inquiry were employed to understand reasons for nonpersistence from ten nonpersisting students' perspectives. Finally, conclusions based on the results of these two forms of inquiry were compared and supportive relationships were established. Relationships across both methods of inquiry were discussed in an effort to better understand and improve retention at a major western research university.

Quantitative Inquiry

Quantitative research allows the researcher to become more familiar with the problem being studied by focusing on facts and outcomes of behavior. Quantitative research uses descriptive and inferential statistics to illustrate analysis of data to show pattern in pursuit of answers to the research questions (Harwell, 2011). Researchers using quantitative methodologies attempt to categorize data into useful segments that can be applied to similar situations (Winter, 2000).

The quantitative portion of this case study used Statistical Package for the Social Sciences (SPSS) Version 21.0 (IBM Corp., 2012) predictive analytics software on quantitative institutional data from the Banner system to determine which factors from the data predict success in the engineering program of one western university. Banner is an administrative software application developed specifically for higher education institutions by Systems and Computer Technology Corporation (SCT). Banner maintains student, alumni, financial and personnel data. SPSS (IBM Corp., 2012) is a statistical analytics tool which can be used to quantify the effect of independent variables discussed below on the dependent variable in this study; namely persistence in engineering.

The University Site

The site university, which is called “a major western research university” in this study, has a STEM-Dominant Carnegie classification and is well known in the region for the strength of its Accreditation Board for Engineering and Technology (ABET) accredited engineering programs. A major western research university offers degrees in civil, computer, biological, mechanical, electrical and environmental engineering. Particularly relevant to this study, these engineering degrees have a preprofessional and professional course of study. The preprofessional program constitutes the freshman and sophomore years, and the professional program includes the junior and senior years. Entry into each engineering discipline’s professional program is predicated on the student’s performance in the preprofessional program. After three failing grades in the preprofessional program, the student may not be allowed to enter into the professional program.

The Population

The population for this research was declared engineering majors at a major western research university from academic year 2006-2007 through 2012-2013. The population was divided into two groups: persisters and nonpersisters. Nonpersisting engineering students were included on a list maintained by the engineering college since 2011 of students wishing to transfer out of engineering. From January 1, 2011, through February 26, 2014, there were 383 students who requested a transfer out of an engineering major at a major western research university. Data on the destination of these students who left engineering were not collected. None of these students had been accepted into a professional engineering program. These 383 students comprised the group analyzed as nonpersisters. The group of nonpersisters were chosen because they had identified themselves as nonpersisting students by signing the engineering college's list as they left engineering. This population was not sampled. All 383 students were included as nonpersisters.

Persisters were defined as students who had successfully completed a 3000-level engineering course. The engineering college at a major western research university does not allow students to take a 3000-level engineering course without acceptance into one of the professional engineering programs. A major western research university had records of all students who had taken a 3000-level engineering course from academic year 2006-2007 through 2012-2013. During this time period, 2,088 students had successfully completed a 3000-level engineering course. One of the variables from the institutional data collected on engineering students was their projected graduation date.

Of these 2,088 students, the 383 with the latest expected graduation dates were purposely selected for analysis. This was done to balance the number of students in persisting and nonpersisting groups. In an effort to match persisting and nonpersisting students over similar timeframes, latest expected graduation dates were used to narrow the list of persisters. This method of selecting persisters had an added benefit of using students whose records were newer and more complete than those persisters who had taken a 3000-level course in 2005 or 2006. Data collected during these years may not have adequately been transferred to Banner or the data may have been collected in a different manner. Thus, comparisons of non-Banner data with Banner data were discouraged since they may not be consistent.

After the list of 383 persisters and 383 nonpersisters had been compiled, a request was made to the registrar's office at a major western research university to provide data for each of these students from the university's Banner record keeping system. It should be noted, that at no time did the researcher have access to any personal identifying data on the students. The engineering college had coded identifiers of nonpersisting students, and had not shared the key with the researcher. A sample of the institutional data collected on the 383 persisters and 383 nonpersisters is included as Appendix B.

Analysis helped determine each independent variable's effect on the tendency of engineering students to persist through the university's preprofessional program, and enter the professional program in one of the following engineering disciplines: civil and environmental engineering, mechanical engineering, electrical engineering, biological engineering, and computer engineering. The dependent variable in this analysis was the student inclusion in the group of persisters or nonpersisters. Independent variables were chosen based on availability of the data coupled with importance based either on a review of the literature or variables of local institutional interest. A summary of the independent variables analyzed in this study is shown in Table 1.

Table 1

Independent Variables Analyzed for Contribution to Engineering Student Persistence

Independent variable	Reason for inclusion
Gender	Common variable in literature
Age	Common variable in literature
Residency status	The institution charges higher tuition to nonresident students. It is of interest to see if the additional cost affects persistence.
High school GPA	Common variable in literature
Math act score	Common variable in literature
Composite act score	Common variable in literature
Scholarship Recipient	Common variable in literature
Financial aid	Common variable in literature
Lived on campus	Common variable in literature

Methods of Statistical Analysis of Institutional Data

Descriptive and inferential statistics were used to compare the persisting group with the nonpersisting group. Contingency tables were used to examine the relationship between nominal and ordinal information derived from the institutional data. Significant relationships were reported using chi square or Pearson’s chi-square statistics and associated *p* values at 0.05, a common standard for significance determination (Hogg, 1980). A chi-square test is a statistical test commonly used for testing independence and goodness of fit. Testing independence determines whether two or more observations across two populations are dependent on each other. The chi-square test determines whether one variable helps to estimate the other (Hogg, 1980). Inferential statistics were used to explore the differences between persisters and nonpersisters. A 2-tailed independent *t* test for equality of means can be used to determine if two sets of data are significantly different from each other. Because the *t* test for equality of means is appropriate for comparing small sets of quantitative data, it was determined to use *t*-test statistics to test the difference in means on continuous variables (Hogg, 1980).

Qualitative Inquiry

The qualitative portion of this research project was crafted with an orientation in constructivist theory, which maintains that people's truths and realities are not "universally known" (Guba & Lincoln, 2005, p. 204) and objectively measurable. Rather, social truths and realities are understood to be created "transactionally" (p. 204) through negotiations, dialogues, and other forms of communication and interaction. In this study, the truths and realities of undergraduates who left a university engineering program are understood to have been constructed through their experiences and perceptions. As Cannella and Lincoln (2011) reminded us, "All truths are partial and incomplete" (p. 95); however, some aspects of participants' lived realities can be captured in the stories they tell about their experiences leaving the engineering program.

Situated within this epistemological orientation, this research project explores the experiences of ten undergraduate students who have dropped out of engineering. Narrative inquiry “revolves around an interest in life experiences as narrated by those who live them” (Chase, 2011, p. 421) and allows the researcher to gain understanding of these truths and realities. As Chase explained, narrative is “meaning making through the shaping or ordering of experience, a way of understanding one’s own or others’ actions, of organizing events and objects into a meaningful whole, of connecting and seeing the consequences of actions and events over time” (p. 421). This study was framed around the importance of narrative in many ways.

With approval from the local institutional review board for research with human subjects, I recruited voluntary participants from the list of 383 nonpersisters. Working with the engineering college, I wrote a narrative e-mail message asking for volunteers and sent it to the 18 students who had left the university’s engineering program in January and February of 2013. Receiving no responses, I rewrote the message and sent it to the other 365 nonpersisters. I received only ten responses, and interviewed each of these ten. Although the number of participants was low, the number of participants allowed for deep and detailed inquiry into the experience of each participant—qualities that are highly valued in qualitative and narrative research (Chase, 2011; Glesne, 2006). Nine students were male; one was female. All were eager to share their stories for the benefit of future students.

Focusing on the students' lived experiences and their narratives about these experiences, I asked each participant to draw an illustrated map of their journey into and out of the engineering program and to bring that map to our interview. This "journey mapping" exercise was adapted from Nyquist et al. (1999), who asked study participants to visually capture their journey through graduate school. They found that the drawings "provided powerful glimpses into the realities of graduate student lives today" (Nyquist et al., 1999, p. 18). As I met with each participant for 90-minute interviews, they shared the journey map they had drawn and then narrated to me their story of wanting to become engineers, enrolling in the engineering program at the university, struggling in the program, and eventually leaving it and finding success elsewhere. I had prepared five interview guide questions based on research question number two, included in Appendix C, to ensure each participant discussed similar topics so I could compare their answers with the other participants. I realized that the prepared research questions were not necessary as the journey maps were enough to keep the interviews on point. Later in the interview, I asked participants what advice they would give future engineering students to help them persist in the program and then what advice they had for the engineering college at a major western research university that might increase persistence of undergraduate engineering students. All journey-mapping interviews were audio recorded and then transcribed. In the end, data consisted of the graphic journey-mapping products; interview transcriptions of student explanations of their journeys into and out of engineering; and my own researcher reflections based on research literature in engineering education, qualitative research, and my experience as an engineering undergraduate over 20 years ago. Often referred to as triangulation (Ellingson, 2011; Patton, 2001: Richardson, 2000), gathering multiple forms of data is common practice in qualitative research and helps establish the trustworthiness of the findings and analysis (Glesne, 2006; Hollway & Jefferson, 2000; Lincoln & Guba, 1985; Olesen, 2011; Patton, 2001).

Because each participant's story was unique and revealing, their individual cases make up the Participant Stories section. As I studied the narratives of all participants, I utilized the fundamental qualitative research methods of analyzing the narrative data for themes and subthemes (Chase, 2011; Glesne, 2006). Comments were transcribed from digital recordings of the interviews. These transcriptions, together with the journey maps provided by the participants, served as the data set from which themes were later identified. As Hsieh and Shannon (2005) expressed, qualitative analysis involves, "subjective interpretation of the content of text data through a systematic classification process of coding and identifying themes or patterns" (p. 1278). Subjective interpretation of the data common in qualitative analysis allows for making sense of the participants' experiences with participation of the researcher (Lincoln & Guba, 1985).

The Analysis section focuses on the major themes of individual and institutional factors related to persistence, factors that are well documented in the research literature, and also on several issues that are not addressed in the literature but that arose from this study. I was unprepared for the deep emotions participants expressed; they led me to relive my own experience with undergraduate engineering education.

Mixed-Methodological Inquiry

As a small, but growing form of inquiry, mixed-methodological inquiry offers a deeper understanding of results gained by multiple methods (Harwell, 2011). Johnson and Onwuegbuzie (2004) described mixed-methodological research as follows.

> Mixed methods research is formally defined here as the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study. Mixed methods research also is an attempt to legitimate the use of multiple approaches in answering research questions, rather than restricting or constraining researchers' choices (i.e., it rejects dogmatism). It is an expansive and creative form of research, not a limiting form of research. It is inclusive, pluralistic, and complementary, and it suggests that researchers take an eclectic approach to method selection and the thinking about and conduct of research. (pp. 17-18)

Borrego et al. (2009) categorized the design type for mixed methodological study into four categories. These include triangulation design, embedded design, explanatory design, and exploratory design. Creswell et al. (2002) described six overlapping design types for mixed-methodological study. Design types vary in the sequence of the quantitative portion relative to the qualitative portion of data collection, the weighting of results, and the purpose of utilizing both qualitative and quantitative data collection methods (Harwell, 2011). This study uses a modified embedded design type of mixed-methodological inquiry. Data collection for the quantitative and qualitative portions of the study were collected concurrently, thus no attempt was made to use the results from one form of inquiry to inform the other. Results from the qualitative portion of the study were used to compliment and deepen the understanding of the results from the quantitative portion. Thus, the weighting of the quantitative results was greater from the perspective of validity. Adding the qualitative results was not, however, an attempt to formally validate the quantitative data through triangulation, but served simply to help add a depth to the quantitative results not possible by quantitative inquiry alone.

In Chapters V and VI of this study, results from the quantitative and qualitative portions of this study are explored to discuss commonalities. The confluence of results drawn from both methods of inquiry is discussed to provide color to the quantitative results, and thus increase and deepen understanding. Results from the quantitative portion of the study were analyzed to determine if the researcher could find links to the qualitative results. Linkage and its explanation were determined based on the literature, study data collected, and the researcher’s own experience.

CHAPTER IV

FINDINGS

Research Question One

Which factors are associated with persistence in engineering? Included in this institutional data are demographic descriptors (gender, age, marital status, residency status), secondary-level profile (high school GPA, ACT scores), and other factors of interest (completion of LDS mission, scholarship, financial aid, and living on campus). Using SPSS Version 21.0 software, the 383 persisters and 383 nonpersisters were compared using “successful entry into an engineering professional program” as the dependent variable, and independent variables as shown in Table 2. Two methods of analysis were used to compare the persisting group with the nonpersisting group. The first method used the contingency tables to determine if the combination of each independent variable and success or failure was significant as measured by the Pearson chi-square statistic or Fisher’s exact test (for two-by-two tables) at the 0.05 level (Hogg, 1980). The use of Fisher’s Exact Test or chi-squared statistics was restricted to nominal or ordinal level variables. The second method used a *t* test to determine if the mean of the independent variable, for continuous variables only, for successful students was significantly different than that of unsuccessful students. A detailed explanation of the results of statistical analysis of each independent variable is found below.

Table 2

Summary of Results for Independent Variables Analyzed for Contribution to Engineering Student Persistence

Independent variable	Question analyzed	Analysis Technique Employed	Significant difference in the group means? p=0.05
Gender	Are female students less likely to persist?	Contingency tables	No
Age	Are older students more likely to persist?	*t* test	Yes
Residency status	Are Utah residency, nonresidency, or international residency factors in student attrition?	Contingency tables	N/A
High school GPA	Are students with higher high school GPA more likely to persist?	*t* test	Yes
Math ACT score	Are students with higher math ACT scores more likely to persist?	*t* test	Yes
Composite ACT score	Are students with higher composite ACT scores more likely to persist?	*t* test	Yes
Scholarship Recipient	Are students with scholarships more likely to persist?	Contingency tables	No
Financial aid	Are students with financial aid more likely to persist?	Contingency tables	Yes
Lived on campus	Are students who lived on campus more likely to persist?	Contingency tables	Yes
Marital Status	Are married students more likely to persist?	Contingency tables	Yes

Significance of Gender on Persistence

The institutional data used for analysis in this study included data on 766 students. Half of these students were persisters, the other half were nonpersisters (see p. 33 for a description of how persisters and nonpersisters were chosen). Results shown in Table 3 indicate that gender was not a significant predictor of persistence (chi-square =

0.248, $p = 0.05$). The “% persisters” column shows the percentage of the data for each variable that belong in the group of persisters. The “Pearson chi square” provides the statistic used to determine if the difference in the number of each variable belonging in the group of persisters is significant with significance defined as < .05. Female students are slightly less likely to be persisters than male students. Gender does not appear to be a significant factor in predicting persistence for the population analyzed.

Table 3

Effect of Gender on Persistence

Variable	# of data for each variable	% Persisters	Pearson chi square	Significant?
Female	84	44.0	.248	No
Male	682	50.7		

Significance of Age at Expected Graduation Date on Persistence

The institutional data contained a projection of graduation date for each student. Comparing this date with the student’s birthdate enabled determination of each student’s projected age at graduation. When graduation age was used as a continuous variable *t*-test results also showed that age was a significant predictor of persistence (Table 4). The mean projected age at graduation for persisters is significantly higher than the mean projected age at graduation for nonpersisters. Older students were more likely to persist than younger students.

Table 4

Effect of Projected Age at Graduation on Persistence, t Test

Variable	*N*	Mean projected age at graduation	*t* test for equality of means	Significant at *p*=0.05?
Persisters	383	28.58	.000	Yes
Nonpersisters	383	25.57		

Significance of Residency on Persistence

The institutional data defined student residency as "R" for in-state resident, "N" for out-of-state resident, and "I" for international students. Table 5 includes descriptive statistics on these residency-related variables. It can be inferred from Table 5 that residency is a factor in persistence for our subject population. Nonresident students are less likely to persist and international students are more likely to persist when compared with in-state resident students using the chi square test.

Table 5

Effect of Residency on Persistence

Variable	*N*	% Persisters	Pearson chi square	Significant at *p*=0.05?
In-state resident (R)	658	50.0	.001	Yes
Out-of-state resident (N)	65	35.4		
International student (I)	43	72.1		

Significance of High School GPA on Persistence

The institutional data contained the high school grade point average (GPA) for 529 of the students. Half of the 529 students with high school GPA data were persisters, and half were nonpersisters. The median high school GPA was 3.74. Using high school GPA as a continuous variable, mean high school GPA of persisters was compared with that of nonpersisters (Table 6). Results from *t*-tests indicated that the difference was significant (t = 0.012, $p = 0.05$). Table 6 includes the inferential statistics for high school GPA-related variables. It also shows that the mean high school GPA for persisters was significantly higher than the mean high school GPA for nonpersisters. The inferential analysis of high school GPA-related variables indicates that students with higher high school GPAs were more likely to persist.

Table 6

Effect of High School GPA on Persistence, t Test

Variable	*N*	Mean high school GPA	*t* test for equality of means	Significant?
Persisters	208	3.67	.012	Yes
Nonpersisters	321	3.58		

Significance of ACT-Math and ACT-Combined Scores on Persistence

Most of the students took the American College Testing (ACT) test to gain admission into a major western research university. The students' scores on the math portion of this test (ACT-Math) as well as the combined scores (ACT-Comb.) were considered. Table 7 includes the inferential statistics for ACT-Math. Table 8 includes the inferential statistics for ACT-Comb. From Tables 7 and 8 it can be seen that the mean ACT-Math and ACT-Comb. Scores for persisters are significantly higher than those of nonpersisters.

Table 7
Effect of ACT-Math on Persistence

Variable	*N*	Mean scores	*t* test for equality of means	Significant?
ACT-Math: Persisters	231	27.32	.001	Yes
ACT-Math: Nonpersisters	324	26.09		

Table 8

Effect of ACT-Comb. on Persistence, t Test

Variable	*N*	Mean scores	*t* test for equality of means	Significant?
ACT-Comb: Persisters	233	26.14	.001	Yes
ACT-Comb: Nonpersisters	324	25.10		

Significance of Scholarship on Persistence

The institutional data used for analysis in this study included data indicating if students had received scholarships. Table 9 includes descriptive statistics for scholarship related variables. The receipt of a scholarship had no significant effect on persistence.

Table 9

Effect of Scholarship on Persistence

Variable	*N*	% persisters	Pearson chi square	Significant?
Received scholarship	303	48.2	.416	No
Did not receive scholarship	463	51.2		

Significance of Financial Aid on Persistence

The institutional data used for analysis indicated if students had received financial aid. Table 10 includes descriptive statistics for financial aid-related variables.

Table 10 illustrates that receipt of financial aid had a significant effect on persistence. Students who received financial aid were more likely to persist than students who did not receive financial aid.

Table 10

Effect of Financial Aid on Persistence

Variable	*N*	% persisters	Pearson chi square	Significant?
Received financial aid	419	61.6	.000	Yes
Did not receive financial aid	347	36.0		

Significance of Living on Campus to Persistence

The institutional data used for analysis in this study included data indicating if students had lived on the main campus of a major western research university. Table 11 includes descriptive statistics for living on campus-related variables. Living on campus had no significant effect on persistence.

Table 11

Effect of Living on Campus on Persistence

Variable	*N*	% persisters	Pearson chi square	Significant?
Lived on campus	223	50.2	.937	No
Did not live on campus	543	49.9		

Significance of Serving an LDS Mission on Persistence

The institutional data used for analysis in this study included data indicating if students had served an LDS church service mission (Church Mission). Data indicated that only 13.5% of students had served Church missions. This seems surprisingly low considering the LDS population at a major western research university, although not officially tracked, is assumed to be 50% to 60%. The researcher made inquiries into the source and validity of these data, but verification was not available. Analysis of the data provided showed students who served an LDS mission were less likely to persist than their peers who did not serve an LDS mission. Because students who serve LDS missions are more likely to be older and married than their peers, it would be consistent with other findings of this study that they would persist at a higher rate. Possible explanations for this inconsistency may include the source data, the general timing of an LDS mission, and the negative effect a leave of absence can have on the flow of undergraduate education. Because Church mission related data could not be verified, and because this information is unique to very few universities and results cannot be easily generalized to other universities, there will be no further analysis of this finding.

Significance of Marital Status on Persistence

The institutional data used for this analysis included data indicating if students reported themselves as married, single, or divorced. Because only three students reported as divorced, this data point was dropped. Table 12 includes descriptive statistics. Married students were more likely to persist in engineering.

Table 12

Effect of Marital Status on Persistence

Variable	*N*	% persisters	Pearson chi square	Significant?
Married	217	61.8	.000	Yes
Single	493	45.0		

Research Question Two

The perceptions of ten nonpersistent engineering students were analyzed to investigate why they left the engineering college at this major western research university. Table 13 includes eight factors in which the differences between persisters and nonpersisters were statistically significant. As discussed earlier, the data dealing with serving an LDS mission was removed, leaving seven statistically significant factors. Students may have chosen to leave engineering because of one, or a combination of several, of these factors. Possible reasons for leaving include students were younger than average, students were nonresidents, students had lower than average high school grades and ACT scores, students lacked financial aid, and students were unmarried. Seeking deeper answers to research question number two, qualitative inquiry was utilized to compliment the quantitative findings (Meyer & Marx, 2014). From the group of 383 nonpersisters included in the research population, ten students volunteered to be interviewed. These students relayed the stories of their journeys into and out of engineering. By carefully comparing the narratives and journey maps of all ten participants, common themes leading to withdrawal from engineering were drawn from the participant stories. A summary of these common themes is shown in Table 14.

Table 13

Summary of Statistically Significant Results for Independent Variables Associated with Engineering Student Persistence

Independent variable	Question analyzed using contingency tables	Method of Analysis Used
Age	Are persisters older than nonpersisters?	*t* test
Residency status	Are Utah residency, nonresidency, or international residency factors in student attrition?	Contingency tables
High school GPA	Do persisters have a higher HS GPA than nonpersisters?	*t* test
Math ACT score	Do persisters have a higher math ACT score than nonpersisters?	*t* test
Composite ACT score	Do persisters have a higher composite ACT score than nonpersisters?	*t* test
Financial aid	Are students with financial aid more likely to persist?	Contingency tables
Marital Status	Are married students more likely to persist?	Contingency tables

Table 14

Reasons Cited by Participants for Leaving Engineering

Reasons for leaving	Participants who stated this was a factor
Individual factors	
Failure to integrate into engineering culture	Bob, Jenny, Zach, Karl, Abe, Bill, Scott, John, Charles, Jim
Disappointed	Bob, Jenny, Zach, Karl, Bill, John, Charles, Jim
Overwhelmed	Bob, Jenny, Zach, Karl, Abe, Bill, Scott, John, Charles, Jim
Institutional factors	
Inadequate high school preparation	Bob, Jenny, Karl, Abe, Bill, Scott, Jim
Loss of motivation to study due to program rigor	Bob, Jenny, Zach, Karl, Bill Scott, Jim
Poor teaching/mentoring	Jenny, Bill, Scott, John, Charles, Jim
Inadequate advising	Bob, Jenny, Zach, Karl, Bill, Jim
Unwelcoming culture of engineering college	Bob, Jenny, Zach, Karl, Bill, Scott, John, Jim
Financial pressures	Zach, Bill, Jim
Poor academic performance	Bob, Jenny, Zach, Karl, Abe, Bill, Scott, John, Charles, Jim
Disinterested	Jenny, Charles

Participant Stories

Each of the participants drew their journey through engineering on a journey map, which they brought to the interview. I provided them with an example from Nyquist et al. (1999) that used journey mapping to enable students in engineering doctoral programs to describe their experiences. This approach was comfortable for participants and the interviewer.

In this section, each participant's journey map is used as a guide for their story into and out of engineering. I found that the journey maps kept participants on target throughout the interview. Near the end of the interview, I asked each participant what advice they would give to future students and what advice they would give to the university's engineering college to increase persistence. The participants offered thoughtful suggestions for future students and the university's engineering college, which are included at the end of each of their stories. All names used in this paper are pseudonyms to protect the identities of the participants.

Bob

Bob never really considered any field other than engineering. As a consequence leaving engineering was difficult for him. "I thought of myself as an engineer. I called myself an engineer.... After I could see it was over, I really had no idea what I would do," he explained. Bob grew up in a small community with several local chemical manufacturing facilities and many local engineers. As he explained,

> My dad is a chemical engineer, so I guess that influenced me. I also had a really good engineering teacher. He used to work with my dad at the plant, but he decided he wanted to go back and teach. He taught all of my science and chemistry classes…. I could tell he really liked what he was doing and wanted me to be an engineer.

Bob performed very well in his high school science classes, and fairly well, "As and Bs [excellent and above average grades] mostly, but I didn't try very hard," in his math classes. He took advanced placement calculus in high school, but "didn't pass" the test. Bob chose mechanical engineering as his major at the university because of his interest in cars, represented on his journey map (Figure 1). As he said, "I knew I wanted to be an engineer, and I like, you know, how things work, especially cars. I thought mechanical engineering was about as close to cars as I could come here [at the university]."

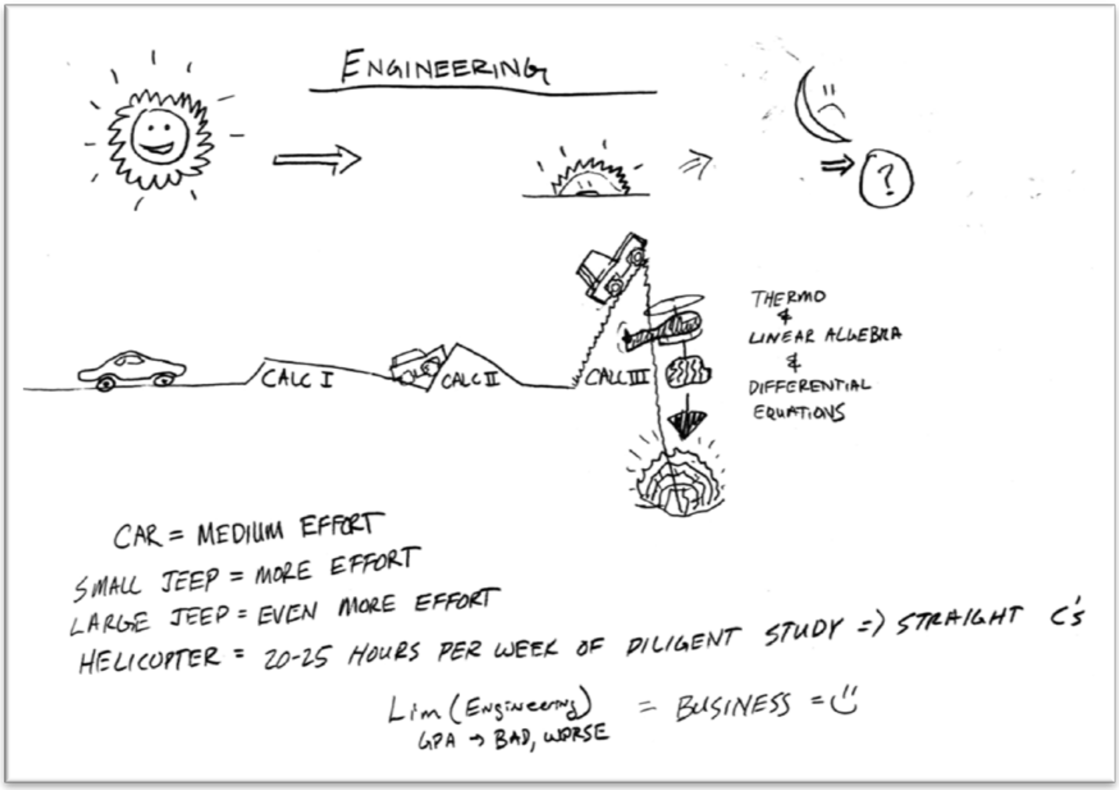

Figure 1. Bob's journey map.

Bob's first semester in the university's engineering program went well. He took Calculus I, a course similar to the calculus class he had recently taken in high school, and earned an A–. Bob signed up for six classes, with each class worth three credits for a total of 18 credit hours. Although this was close to an average workload, Bob was "a little overwhelmed." He related, "I had to study 20 to 25 hours per week just to keep up. I could do it, but it took a lot of time." He took an introductory civil engineering course. "It was pretty easy and I decided that civil engineering was what I wanted to do," he said. At the university, the preprofessional programs for all of the offered engineering disciplines are similar, so it is not uncommon for students to switch between engineering disciplines. Bob's outlook, illustrated as a full sun on his journey map, was bright; but that all changed at the start of his second semester.

Realizing that he had overloaded himself with credits the previous semester, Bob enrolled in four classes (12 credit hours) his second semester. One of these classes was Calculus II. "I think it was a combination of the professor's teaching style and my lack of effort that led to my destruction in this class," he said dramatically. The professor had taught high school math for several years, but Calculus II was his first college teaching experience. As Bob explained:

> About halfway through [the semester] I realized I was doing bad, so I tried to, you know, redouble my effort I guess...then I thought I was doing better in calc., so I sort of moved my effort to other classes, catching up on those.

By then, though, it was too late. Bob failed the class.

Bob's journey map shows the hurdles he faced and the rapidly increasing effort required for him to keep up with the program. The type of vehicle shown on his journey map signifies the level of effort Bob felt was required to keep up. He came to the university believing that a sports car (flash, but with little power) would be adequate for the challenges (hills) he would face. As time goes by, the car is replaced with a small jeep, then a large jeep, and finally a helicopter to signify the increasing effort Bob felt was required of him. As effort increased, his attitude, represented by the setting sun, worsened.

Bob retook, and passed, Calculus II, but failed Calculus III. He moved on to Differential Equations, the next course in the math series for engineers, without retaking Calculus III. "Calc. III wasn't a prerequisite for Differential Equations, so I didn't have to retake that one," he explained. When asked about his chances of making it to the professional program at this point, Bob said, “I was starting to have my doubts, but I thought I would give it a really good effort to see what happened.” Bob failed Differential Equations. This was his third failure, which disqualified him from progressing in the professional engineering program.

Unwilling to give up, however, Bob retook and passed Differential Equations, and began some of the “second year engineering classes like Thermodynamics and Linear Algebra.” These courses are represented on his journey map by the heavy stone; they proved to be an insurmountable barrier for him, even with a helicopter-sized effort. “I listened to and liked the lectures, but I would go home, you know, for the homework, and it was like a totally different thing. The lectures and the homework didn’t line up. They weren’t the same thing,” he said. He had intended to withdraw from the classes before the deadline, but “I just didn’t. I guess I forgot.” The moon on his journey map represents the diminishment of his excitement. He sensed that “engineering might not be for me.”

Coming to grips with his need to change majors, Bob visited the adviser in the university’s business department. “I went to the adviser there and they told me what classes to take and said [that] after I took a couple of classes, I could apply to get into the business school.” Bob got straight A’s, perfect grades, his first semester taking business classes. In fact, since he had not officially withdrawn from engineering, Bob made the Engineering Dean’s List due to his good grades. Bob felt he was “saved” by the business department. “They really care about me,” he said. He plans to graduate “much sooner” in business than he would have in engineering. “They told me I would graduate next year, and so far that is holding true,” he said. Bob completed his journey map with an equation borrowed from calculus that shows he had reached his limit with engineering as his grades had gone from bad to worse. His failure in engineering led him to change his major to business – this change led to happiness.

Bob focused his advice to future students and urged them to take full advantage of the help offered by the engineering college. “I wish I would have used the tutors. I guess I knew they were there. I just never used them,” he said. He suggested that the engineering college “make more of an effort” to guide students to the tutors. He also suggested that the engineering college become involved with struggling students much sooner. Bob also wished he had understood the rigors of the engineering program at the beginning of his studies.

Jenny

“Looking back on it, I wish I had known what I was getting into,” Jenny said when we met. As a female who had earned perfect grades in high school and who desired to become a civil engineer, Jenny was offered scholarships at several universities. She had very high test scores and grades and excelled in math and science—qualities she depicted on her journey map as the building with pillars (Figure 2). The well-regarded engineering program at the university was not a factor in her choice to enroll as a civil engineering major. “It was the scholarship and the distance from home. I wanted to be far enough away from home to be my own person,” she remarked.

Jenny’s preuniversity experience was successful. As she explained, “I have maintained a 4.0 [perfect grade point average (GPA) on a 4-point scale] since seventh grade.” But, she felt she lacked depth in “key areas” necessary for preparation in engineering. “I didn’t know anything or have any background in computer programming or physics,” she said. Her calculus teacher in high school was “great,” she told me. “He made the math fun.” Her physics teacher, however, “would put me to sleep, so I transferred out and took biology instead.” After she decided to attend the university, she looked into majors and chose engineering “because of the challenge.”

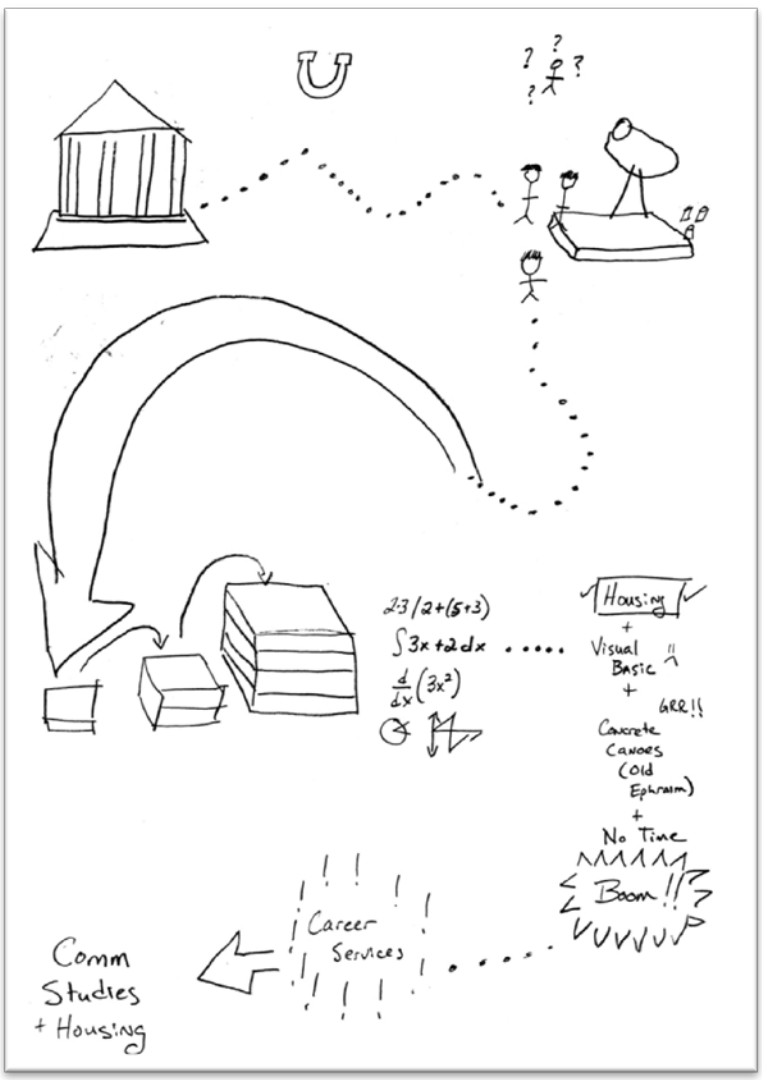

Figure 2. Jenny’s journey map.

She investigated the opportunities available to her as an engineering student while she was still in high school and began her planning. Jenny attended a summer camp offered by the university, shown on her journey map as the drawn “U” (the name of the university, under the “U,” has been removed to maintain its confidentiality). She also obtained an undergraduate research fellowship, which allowed her to work at a civil engineering experimental laboratory her freshman year. On her journey map, this laboratory is depicted as a concrete mixer with her peers gathered around and operating it. Jenny, surrounded by question marks, does not fit in. “I didn’t know enough to contribute much,” she said. Jenny also felt that her petite size kept her from participating in the physically demanding work at the lab.

Although she was surprised by the rigor of the program, depicted on her journey map as books of increasing height and complicated formulas, Jenny continued to do well. “My whole first year went well. I wasn’t really working, so I had plenty of time to devote to school.” Jenny fulfilled her remaining math requirements by taking Calculus II and III in the university’s honors program. “My teacher was great, just great. I remember about halfway through the first term, him sitting the whole class down and saying, ‘Hey, look, you are all struggling because this is really hard.’” Jenny’s first exposure to civil engineering was a surveying class she took her first year at the university. She had heard the surveying class was a “weed-out” course used “to separate out people who couldn’t really do it.” As a female engineering student, Jenny was in the minority. “It was something I was keenly aware of,” she explained. Nevertheless, she built relationships with her fellow students. “They wanted me in their group because they knew I was smart and worked hard.... I started to feel like I could fit in," she said.

In the first term of her second year, Jenny's perception of engineering changed drastically. She reached out to an engineering group for women and "was convinced" to participate with a group project building a competitive concrete canoe. Jenny also started a new job and "didn't have enough time to do everything to my standards." Feeling pinched for time, she began to withdraw from the clubs. "I didn't have time to be as involved as I wanted to be, you know, to be committed. I didn't want to fail anybody," she explained. She had enrolled in two engineering courses and one required computer-programming course for the semester. "I had no background, none in computer programming. The class was useless for learning. I had to do it all on my own," she said. The combined pressure of the difficult computer programming course and her employment, as depicted by the column of pressure leading to an explosion on her journey map, caused Jenny to reconsider her situation. She explained:

> I thought, "Something is not right about all this stuff I am doing. Therefore, something needs to change. I don't like this...." The computer class was the last straw. So, the computer class leads to feeling disengaged from everything, leads to a realization, "What if I am not an engineer anymore?"

Jenny felt "a ton of relief" when she thought about leaving engineering. Still protective of her perfect GPA, she withdrew from the computer programming class and changed the other two engineering classes to pass/fail, rather than a grade. Although relieved to "be out of a bad situation," Jenny "had no idea" where she would end up at the university. After careful study of a few majors that interested her, she settled on a communications major that was "both challenging and interesting." She plans to graduate within her original four-year timeframe and has maintained her perfect GPA.

When asked what advice Jenny would give to future students, she expressed regret about not knowing much about engineering, saying she “wish[ed] I knew what I was getting into.” She advised future students to learn as much as they could about the program before they started it. Jenny felt that she had been caught off-guard by her computer programming class and suggested to future students that they “be prepared.” On the subject of employment during engineering coursework, Jenny said, “In an ideal world, nobody would have a job while being an engineering major.” She explained that her nonengineering-related job took time and energy away from her studies and was a factor in her leaving. Regarding the engineering college, Jenny asked rhetorically, “What was engineering trying to do pushing people so hard?” She explained that she knew the engineering program needed to be rigorous because of the importance of engineering work. “If you build a bridge and you are wrong, people could die,” she said. Still, the coursework became so demanding, even for a high achiever like Jenny, that, “I did think it got to be too much.”

Zach

Zach, a former surveyor and a little older than the other participants, was visibly upset and emotional as he related his experience leaving engineering. As he walked me through his journey map (Figure 3), he described the engineering advising staff as

> very condescending. They gave no positive reinforcement. They sat there with all their power deciding who would hold the title of engineer and who wouldn’t.... They need to realize that I write their check. No other business would put up with advisers who discourage people and just try to weed people out...now I just want to get a degree and get out of here.

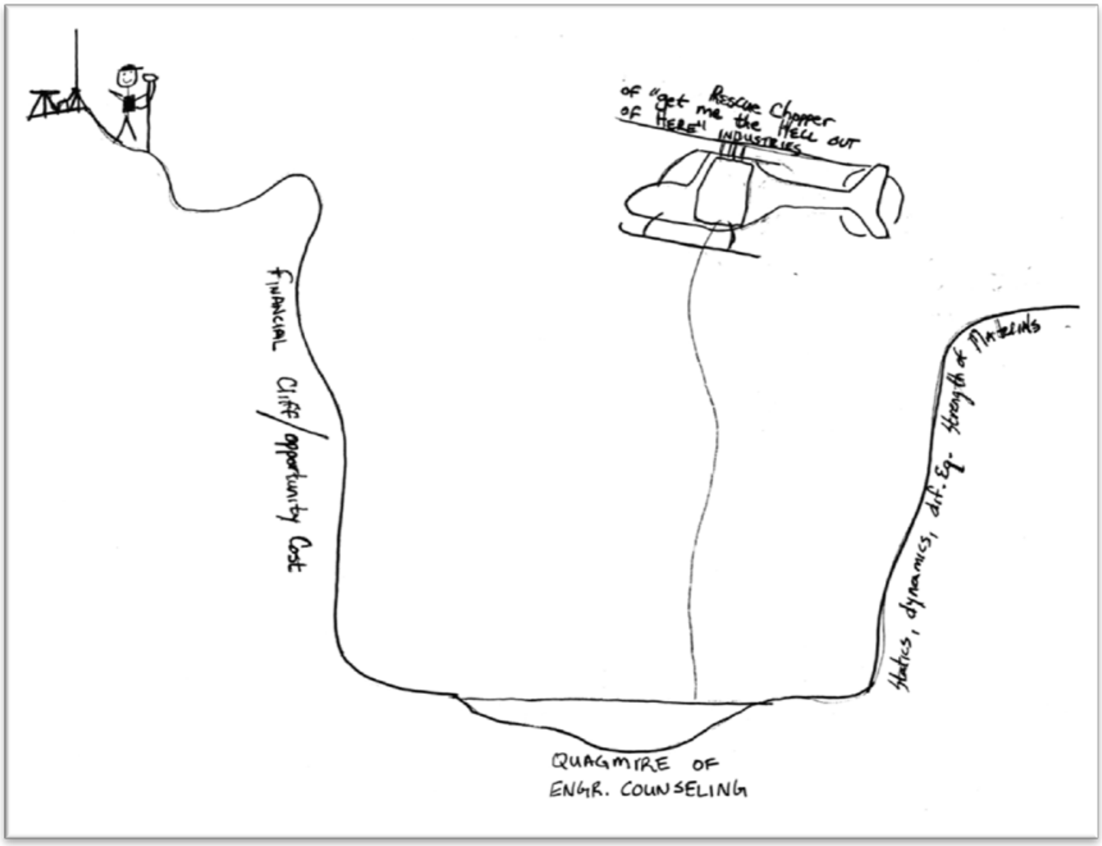

Figure 3. Zach’s journey map.

Zach was very conscious of the cost of his investment in an engineering degree and expressed his frustration with the engineering advisers for their “lack of business sense” – factors that eventually led to his leaving engineering.

Zach’s father was an engineer. Zach had also worked with engineers for several years. He had a high-paying job on a survey crew in a booming petroleum extraction area. At the beginning of his journey map, he shows himself as a happy surveyor on the top of the hill. From this vantage point he could see his vast opportunities for the future. Because of the project-nature of the work, Zach had been “let go” and “rehired” many times in his short career. “I loved the work, but there wasn’t much security,” he said. Noticing that the office workers had a more consistent workload, Zach considered going back to school to pursue a civil engineering degree. “I told my boss and he said to go ahead and they would put me on as an engineer when I was done.” Zach and his wife had planned on completing the purchase of a home the weekend he decided to go back to school. “It was a choice between the house and school. We backed out of the house and chose school,” he said.

Zach began his civil engineering curriculum at a distance campus of the university. “I took every class I could and, it turns out, a couple classes I didn’t need to.” Zach later found out that the advising he got at the remote location was faulty, and, as a result, he took three classes that did not count toward his major. “It was fun, but it would have been nice to keep the $1,000,” he said. With a real sense of the opportunity cost, associated with his degree, Zach was very much concerned with the time involved with getting his degree. On his journey map, the terrain starts to go downhill and becomes a little bumpy, signifying his first challenges with the engineering program. He could still work at his surveying job while he was studying at the remote campus. After three semesters, however, he had exhausted all of the civil engineering courses he could take. He packed up and moved with his wife to the university, hundreds of miles from home.

Zach stopped by the advising office long enough to pick up the yellow scheduling sheet. The suggested coursework for his first semester included Calculus I and a drafting course. He had never drafted before, but immediately “saw the connection between the class and the real world.” He navigated through Calculus I “with a B, but I didn’t give it much effort,” and he enjoyed the drafting class. With most of the preprofessional classes under his belt and a 2.9 GPA on the four-point scale, Zach walked into the engineering advising office for his first face-to-face meeting with an adviser. “I walked in and the first thing she said to me was, ‘Where the hell have you been?’ No ‘hello’ or ‘nice to meet you.’ . . . It went downhill from there,” he said. He felt like he was being disciplined and “discouraged instead of advised” by the adviser. Zach was “scared and extremely discouraged” by the experience. “For the first time, I didn’t know if I was going to make it as an engineer,” he said. Feeling stressed about his ability to stay in engineering, as well as by intense financial pressure, Zach became disappointed with the engineering college and began questioning his future.

Weighing the “value of engineering with all the time and money that is required,” Zach turned to his father for advice.

> He [Zach’s father] said, “Look, it all comes down to how you feel when you get out of classes. Do you feel like you want to go to the library and learn more about the subject, or do you just want to get out of there? If you just want to leave, then you might make it through the program, but you will always be competing with the library guys.”

Zach reluctantly admitted to himself that he “was just happy the classes were over.” Coming to this realization and separating himself from engineering came at a high emotional cost. “I let myself down.... I used to make fun of other [nonengineering] majors, and now here I was one of them, a washout,” he said.

After several more contentious meetings with the engineering advising staff, he learned that he was two additional years away from attaining the degree than he had planned. He felt like an engineering degree was too costly, took too much time, and required more commitment than he was willing or able to give. Although he was not failing, his grades were only average, and he could see that they were worsening as the courses became more demanding. He saw the business department (the helicopter in his journey map) as his savior from the quagmire in which the engineering advising staff was engulfing him. Zach transferred to the business department, where he is now earning straight As. “I don’t even care anymore. I just want to get the piece of paper [diploma] and get out of here,” he said. Zach plans to graduate next spring.

Zach suggested that students move immediately to the main campus of the university. Although he felt the teaching at the distance branch campus was “excellent,” he saw that coordination between the remote and main campus was lacking. He blamed the advisers at the branch campus for the “wasted money” he spent taking three classes that were not on the required list for his civil engineering major. “It might have saved a year to come to [the main] campus in the first place,” he said. This saved year might have made all of the difference for him. Having given a great deal of thought to the improvements he would recommend to the engineering college, he readily offered his advice: “Streamline the program. Trim the fat. Engineers will naturally seek out the stuff they are interested in, so there is no need for general education courses.” Zach still had some strong feelings about the engineering advising department, and commented, “They are just not useful as advisers.” Finally, he suggested that the professors “make sure there is an end-picture relationship.” In other words, he wished some of his courses emphasized the end use of the class material more clearly.

Karl

Although Karl has the utmost respect for engineers and the engineering profession, he really went into the engineering program blindly, as shown on his journey map (Figure 4). He was not prepared for the difficulty and time commitment required to be successful in engineering. As he said,

> I always say you have to be either a genius or 100% committed to be an engineer. I kind of always knew I wanted to major in engineering. I love figuring out how things work. It seems like engineers know a little bit about everything...they make the world go round.

Karl had good grades, “not 4.0 or anything, but pretty good,” through high school. “I took AP [advanced placement] Calculus and AP Chemistry [in high school]. I passed [the AP] Chemistry [exam], but didn’t pass [the AP] Calculus [exam].” Karl entered the engineering program confidently.

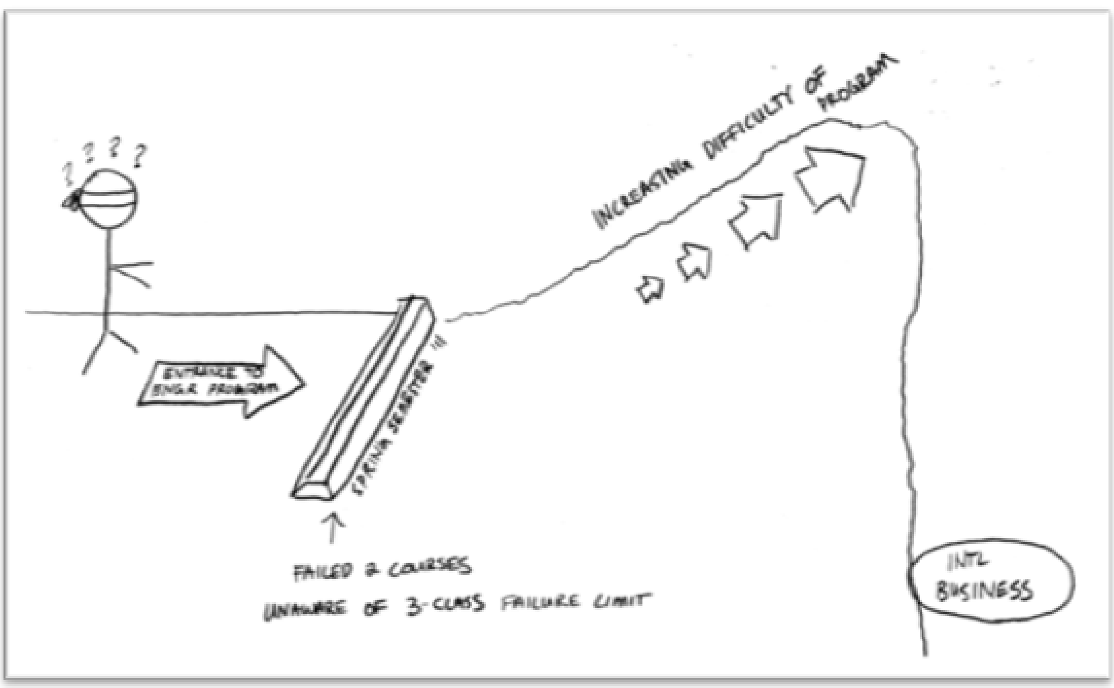

Figure 4. Karl’s journey map.

Having time for only one semester of schooling before he left on a two year church mission, Karl signed up for Calculus I. “I wasn’t ready for college; plus, I knew I would be gone soon. Plus, the teacher was foreign with a really thick accent. I couldn’t really understand him,” he explained. On his journey map, Karl depicted Calculus I as part of the large stumbling block he blindly tripped over. He failed the class and determined he would make up for it when he got back to college. “I wish they [the engineering advisers] would have contacted me and said, ‘Hey, you failed a class and you better watch out,’” he said. Upon his return from church service in Thailand, Karl retook the calculus course and passed it with an A. The University has a policy for returning church missionaries that requires them to take a math placement test. Karl did poorly on this test and had to retake the introductory mathematics course, Math 1010. “It was insulting.” He said. “I went to the class the first day and it was so easy I knew it would be a waste of time. I got in to [Math] 1050. It was pretty easy too; but I had to take it, so I cruised through it.”

Karl worked through many of the preprofessional engineering classes over the next five years. Eight semesters into the four semester preprofessional program, Karl failed two additional classes “because of some personal problems I was having.” Still unaware of the three-strike rule, Karl retook the courses and continued with his coursework. His journey map shows that, even after he stumbled over his three failures, he thought he could still climb the difficult slope and reach the summit of graduation. Unfortunately, he was still blindfolded and could not see the path ahead of him.

Karl decided to visit the engineering advisers. As he said, "I went in because I wanted to continue mapping out what my course would be. I was kind of ignoring the fact that I had, you know, the three strikes." Surprisingly, the adviser he met with, "still... just gave me the piece of paper [schedule of coursework]." So Karl persisted in the program, though he continued to struggle. He explained:

> After the fourth or fifth time [failing a class], I got a letter [from the engineering advisers] saying I was in danger of not qualifying for the professional program…. I always thought I could make some kind of appeal.... I guess I was kind of in denial that I was doing better than I was, and that I could make it into the professional program.

Karl again went to the engineering advisers for help. He spoke with "the main adviser and asked her what my chances were of winning an appeal so I could get into the professional program. She said I wouldn't make it in, and I needed to get out of engineering." Karl was actually grateful for her brutal honesty. "They finally told it to me straight. I think I needed that," he said. This period of Karl's education is represented on his journey map as a steep cliff, the bottom of which he could not see.

Karl blamed his failure on himself, "I felt like I was 80% committed and that wasn't enough.... I thought I could do it, but it turns out I couldn't. I feel like I really let myself down." He was, however, disappointed by the lack of outreach and information from the engineering college. "No one was really watching over me. There was no encouragement along the way...they [the engineering advisers] were just going through the motions.... They could at least have said, 'You are already disqualified.'" Faced with leaving engineering, Karl said "had no idea" what he was going to do. He chose international business, a field he described as "much, much easier." Karl shows this program on his journey map as a “safe” pool, but also on a “much lower level” than engineering. He is currently earning straight As as a business major and expects to graduate in about two years.

After listening to Karl’s story, I was amazed by his patience and understanding with the engineering college. Karl had spent over five years in the preprofessional program without intervention from the engineering college, even after he was disqualified from the professional program. I sensed his genuine concern for future students and his respect for the engineering profession in his replies to my questions. To the students, he advised, “They need to be 100% committed. You have to make a lot of sacrifice, [including] social life and work if you have to.... However much you think you need to study, double that.” To the engineering college, he suggested, “They could have done a better job at kind of gearing you up for the grind. Maybe they need to scare off the people who aren’t fully committed.” On the subject of engineering advising, Karl commented, “I think they could be more vigilant in keeping track of people’s progress, a little more involvement and a little more counseling from the advisers.... I had to take all of the initiative.”

Abe

Abe realized in his third semester of the civil engineering program that engineering was not the path for him. He explained, “My dad and three of my four brothers are engineers. I always planned on it [becoming an engineer], but I just didn’t fit.” With excellent grades in high school and an aptitude for math and science, Abe attended a pre-college engineering workshop during the summer between his junior and senior years. He remarked, “I loved the mechanical aspect of engineering. We worked on robots there [at the precollege engineering workshop] and I thought it was cool that a bunch of people could work together on a project that could really do something.” Abe’s father urged him to become an electrical engineer. Abe’s mother, “thought I should do something other than engineering.” Abe settled on mechanical engineering as, “a compromise for my mom and my dad.” As can be seen on Figure 5, as Abe was considering what to do with his life, the influences of his father and brothers, and his love for math, were strong factors in his choice of major. Abe enrolled in the pre-professional mechanical engineering program in the fall semester. Abe participated in the honors program at the university and had access to, “the honors program advisor. I never met the advisors in the engineering college. My advisor was an older guy and was very helpful. He came up with a pretty aggressive 4-year plan.” Abe’s first semester was full of “challenging” classes, but as Abe explained, “I had my brothers to help me. They had just gone through it, so school was pretty easy for me.” Having passed the calculus AP test in high school, Abe was qualified to take Calculus II his first semester. He did well and earned an A grade. He said, “I never even thought about using the tutors. I had my brother and they were probably better than the tutors anyway.” Abe had a manufacturing processing course his second semester.

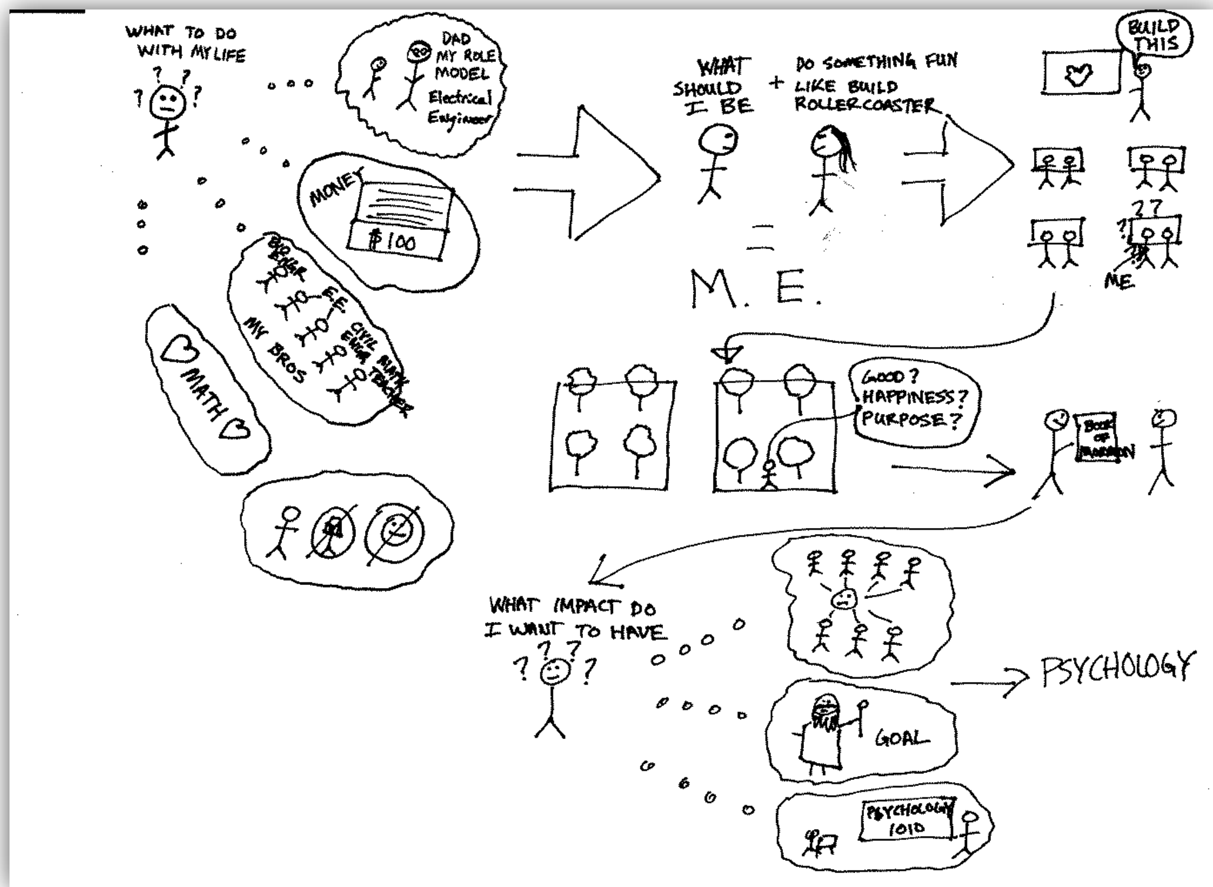

Figure 5. Abe's journey map.

Although he enjoyed the course and had a "really good teacher," Abe "got my [his] first B ever." He explained,

> The course really challenged me and sort of scared me. I had never been challenged academically before. I wasn't as prepared as the other kids [his classmates] for the class. I thought maybe engineering isn't for me. I also had an elective class in the same semester. I think it was called "philosophy and ethics." I loved it and started thinking about doing that instead [of engineering].

This philosophy and ethics class was, "the first elective class I think I had ever taken in my life," Abe noted. Abe spoke with his father about getting out of engineering and finding a career in philosophy. Abe expressed, “My dad was not open to the idea. He told me you can’t make money in philosophy.” As depicted on Figure 5, Abe was very conflicted on his academic future. Abe took a two year leave from school to serve an ecclesiastical mission for his church. During this service he contemplated his future as an engineering student when he got back. “I wanted to serve people with my career. I know engineers provide a great service for people as far as physical things go. I started to think I might want to help with people’s emotional burdens instead of their physical burdens,” he said. After the religious service, Abe started back up in school in the fall semester. He explained, “I went to see my honors counselor when I got back. I explained to him that I had decided to switch majors to psychology. He helped me pick the classes and get signed up.”

Abe went into the engineering administration office to let them know that he was transferring out. “When I signed that paper [form indicating that he was transferring out of engineering] I felt this rush of relief. I was a little confused and unsure, and I felt like I was starting over again, but I was still relieved,” he said. When asked how his family responded to his decision, Abe responded,

> My brothers supported my decision. One of them said it was about time I did something different. My mom was glad that I was doing what I felt was right for me. My dad was skeptical…he still is… about my decision. I feel like I did the right thing.

When asked what advice he had for future engineering students, Abe said, “They really need to examine their motivation for wanting to be an engineer. They need to ask themselves what kind of benefit they want to bring to the world.” His advice to the engineering college to increase persistence was to “help students understand how intense and overwhelming engineering can be." He also suggested the engineering college "pay more attention to individual students and provide mentors." Further he suggested "helping engineering students to be comfortable seeking help. It is hard to switch from getting good grades to getting bad grades."

Bill

"I think I was always mechanically inclined. I tinkered with everything that moved when I was growing up," Bill explained. Figure 6 is Bill's journey map of his experience with engineering and education. In his forties, Bill had "a long road" before enrolling in engineering. "I liked mechanical things, and I always felt drawn to working on cars and bikes. My dad died when I was high school, but before he died he told me he really wanted me to graduate from college and become an engineer. So I started getting things in shape to do that." As depicted on Figure 5, Bill became a mechanic for a few years. "It was still my goal to become an engineer, but life sort of got in the way for a while," he explained.

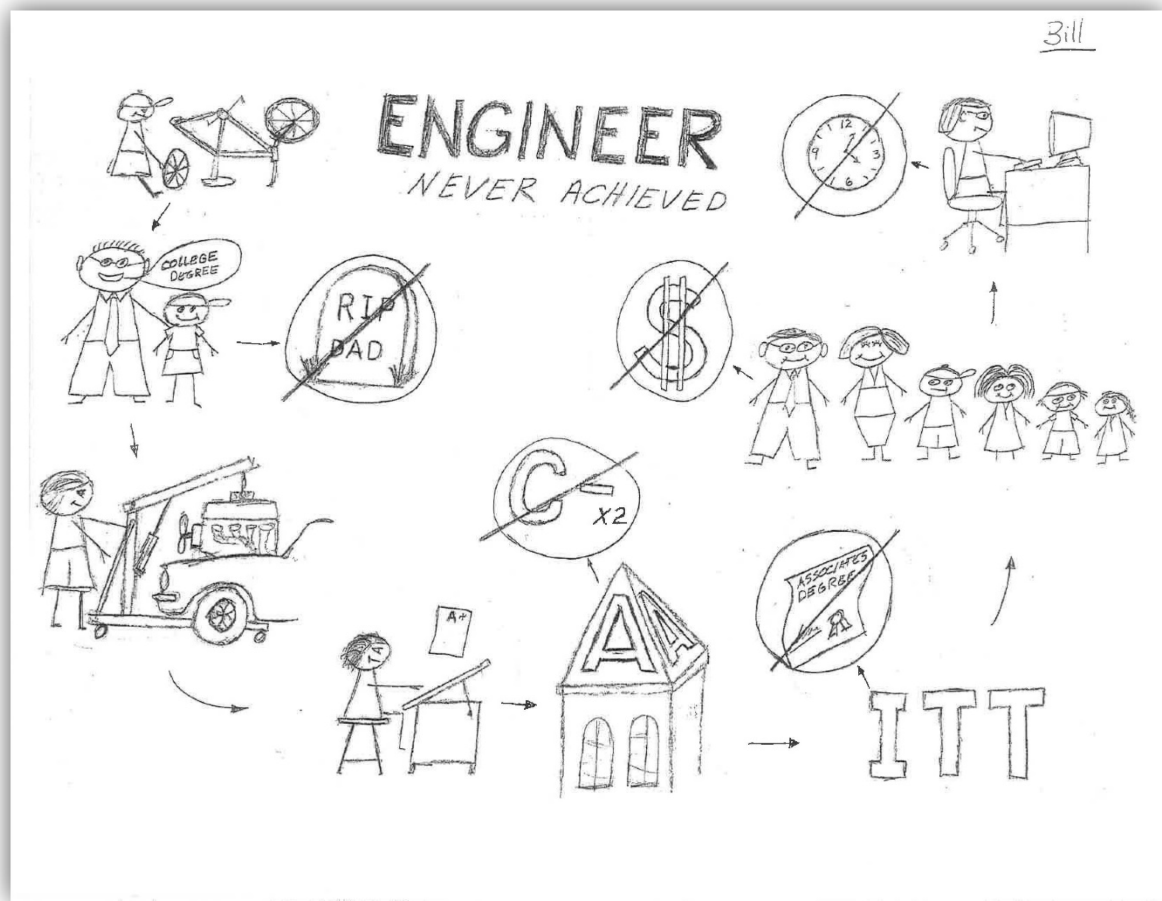

Figure 6. Bill's journey map.

Bill began taking some drafting courses to prepare himself for engineering school. He received good grades in these courses and felt like drafting "came naturally" to him. Bill's first semester as an engineering undergraduate student was "fun and really pretty easy." He got good grades and was very interested in the material. He had chosen civil engineering based on his experience with drafting courses. "It felt like a perfect fit for me," he said.

Bill began taking math courses his second semester. He explained,

> I ended up with a student teacher for the Calculus 1 class. She knew the material, but didn't know how to teach it. I had a bunch of crazy stuff going on in my life at the time. I knew I had to do well in these classes or else I would get kicked out of the [engineering] program. I worked on the classes as hard as I could, but it had been so long since I had done math, plus I was too busy with regular life.

Bill struggled through his math courses in his second semester. "Before I knew it I had two C-'s on my record and I had a whole bunch of math classes left," he explained. Bill considered dropping out of engineering. As he said,

> I didn't feel like I had much of foundation in Calculus I, and I had a bunch of stuff going on at home. I think I could have done it [passed the math courses] if I could have focused just on that. But at that time in my life it was just impossible. I talked to the advisors, but I already knew what the problem was. I just didn't have time.

Dealing with pressure from "two fronts," Bill decided to drop out of the engineering program. "I just didn't have the time or money," he said.

Bill decided to attend a technical drafting school to increase his income and put himself in a position to return to engineering. "Then the family grew and the debt increased," he explained. He obtained a computer-aided designer position which he turned into a career. When asked about his emotional experience leaving engineering, Bill replied, "It was hard. I do feel like I let some people down. I had to be realistic though. The position I was in just wouldn't work. I feel like I do civil engineering without the stamp. It bugs me that an engineering license is not an option for me without starting over completely." Bill suggested to the engineering college that they "set realistic expectations." Also he questioned why the school had a limit on retakes. "They get the same money every time someone takes the class. If I could have, I would have retaken the math classes with a better teacher. There was also no evident real-world connection between the material and the use. It might have just been the student teacher that taught me who didn't know any connections to teach," he said. To future engineering students he said,

> Make sure you really have the time and the resources to do it [complete engineering college]. It takes a lot more time and effort and commitment than you might think. Don't let small things frustrate you to the point that you want to quit. Don't let a five minute conversation with an advisor change your life. You have to have a thick skin to make it through.

Scott

With a solid background in math and science and two brothers who had recently completed engineering, Scott felt he was well prepared to succeed in engineering. He had taken advance placement courses in high school for math and history, and had passed the tests. He explained, "Even though I passed AP calculus in high school, I knew that it was math that killed everybody in college, so I took [Math] 1050 [an introductory math course for the engineering programs] at the community college." He described having had a great experience with math at the community college. Scott earned "A's and B's" in high school and described himself as a "good student."

On advice from his brothers, Scott "paced himself" on the course load he took his first few semesters in the engineering college. "My brothers both struggled to make it through engineering, so they told me to take it slow at least at first," he said. Scott's first semester included Calculus II where he earned a D. He explained, "The material was just tough. I think the teacher was ok. It scared me to get a D. I had never gotten a failing grade before." Scott retook, and passed, Calculus II the following semester. Although he enjoyed the rest of his schedule, Scott was, "…scared by the math. I don't know if it was the teaching style or my learning style, but I just couldn't get the material fast enough." Scott's older brother spoke with him about his diagnosed Attention-Deficit/Hyperactivity Disorder (ADHD) and suggested that Scott should visit a doctor to figure out if he had the same condition. Scott said, "When I told my brother the trouble I was having understanding the material, he told me that he had the exact same problems when he was in my position. He said getting treated for ADHD really helped him."

Figure 7 is the journey map Scott prepared to illustrate his experience with engineering. The drawings and formulas on the left indicate Scott's perceived experience with math at the beginning of his university experience. Scott found a job on campus that allowed him to get some "hands on" experience with some modeling software as indicated by the computer on Figure 7. "The computer modeling experience was really helpful in trying to tie the stuff I was learning to the real world," he said. He expressed that his attitude towards engineering was, "…still pretty good. It [his schooling] was stressful, but I was able to do it. I thought, 'I can do the work, but do I want to do it all of the time?' The stress was starting to bother me." The following semester, Scott failed Calculus III. This was his second failed course and he began considering leaving engineering. He explains,

> I was panicked, but I was still confident I could make it [through engineering] if I wanted to. The problem was I was stressed all of the time. I started looking at other options. I feel like I failed because the teacher just couldn't communicate. I mean, I know it was on me, but it seemed like the teacher just couldn't understand the questions we asked. It was like he was answering a different question. I would get frustrated and watch the class videos at home.

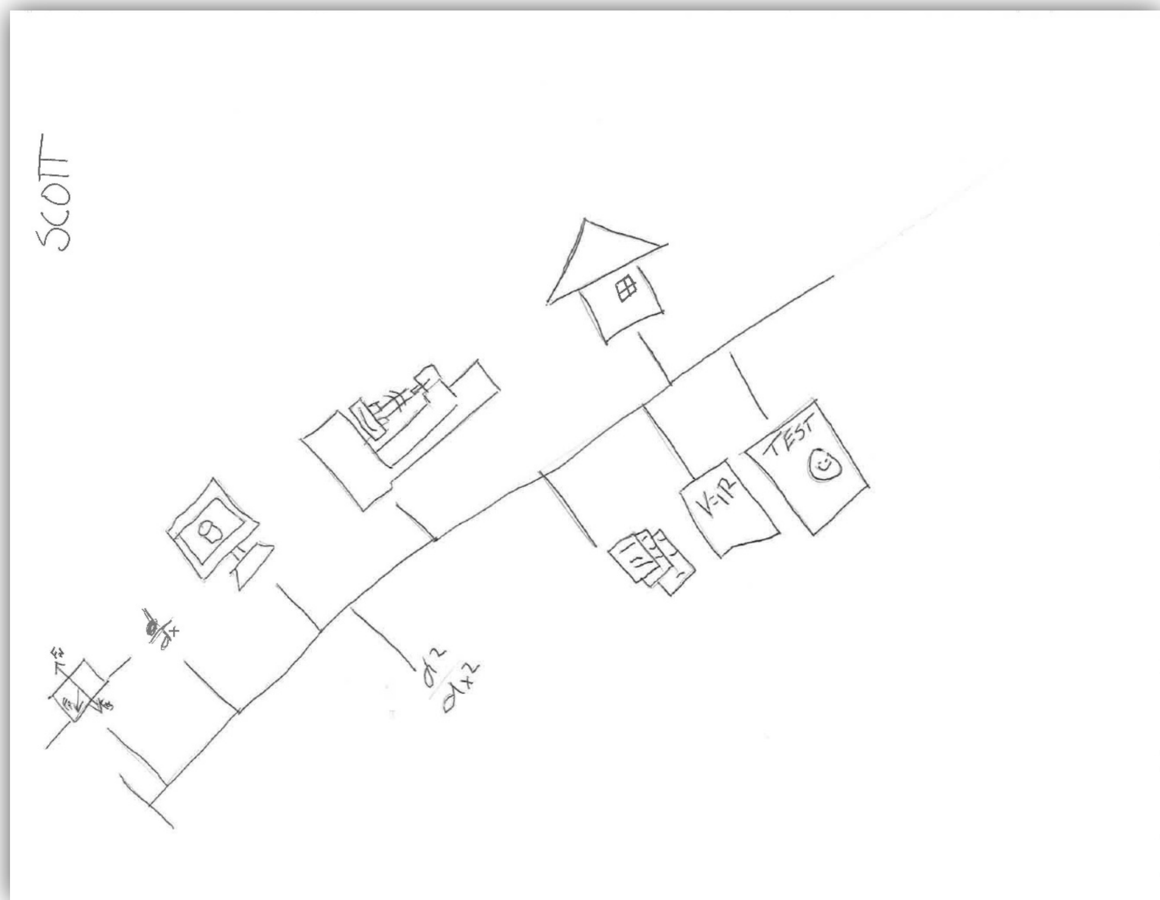

Figure 7. Scott's journey map.

With his stress level rising, Scott reached out to his brothers for help. His oldest brother, convinced Scott had ADHD, urged him to get checked by a doctor before making any decisions about his education. His other brother offered to help him through his courses and asked him to "hang in there." Scott was very close to acceptance into the mechanical engineering professional program. He determined he would take one more semester of engineering before deciding to transfer to another major.

Scott enrolled in a linear algebra course which has described as "too much." Midway through the semester he decided to "find another major." Scott relates, "I spent a day looking at every degree the school offered. I know my decision was fast, but I was tired of being stressed all of the time." Scott chose to transfer into business finance. "I had just bought a home to fix up and that involved a lot of financing decisions…I thought the process was cool," he said. As can be seen on Figure 7, a house built over three sets of documents indicates the firm foundation of interest he had developed for business finance. Scott described the workload he experienced in his new major as, "…far less than engineering, I would guess about a quarter of the workload [as compared to engineering]." He is maintaining good grades and expects to graduate "at about the same time I would have been through with engineering."

Scott's advice to the engineering school to increase persistence included finding ways to give students more hands on experience to help connect the class room to the real world. He also suggested the college do a better job of hiring teachers, "…that can communicate well and help kids to learn." On Figure 7, he shows an instrument used for shaking. This is an illustration of Scott's perception of the shaky foundation engineering students have due to poor instruction and little hands on experience. Finally, Scott commented on the experience he had with engineering advising, saying, "I had very little contact with them because I would always just ask my brothers if I needed help. But I remember when I got my first C, I got a form letter from them saying basically I should give up. I thought that was strange."

To future engineering students Scott recommended taking "as much math in high school or at a community college as they can." Further, he said, "They should really prepare for how hard engineering is."

John

John described his journey map, shown as Figure 8, into and out of engineering as follows,

> So, there was my perception and there was reality. My perception or visualization of what I thought the engineering program was going to be like was this cloud [Figure 8] where I imagined I would have to climb this big hill. I am not naïve. I knew it would be a lot of work, but I visualized that it would we hard, but possible. Then at the end you see me standing on the top of the hill, smiling with my diploma. That is what I thought it would be like. Unfortunately, reality was the program was like a brick wall. I feel like it [the mechanical engineering program] was designed for me to fail.

After ten years of technical work experience, and a strong desire to succeed in engineering, John transferred out of mechanical engineering his first semester. John loved mechanical things and putting things together. He graduated from high school where he, "…was an average student. I got about a 3.0 [grade point average], but I didn't really apply myself…I knew I was smarter than that." John went to work in telecommunications, and worked himself up to a "senior analyst" position. He said, "It was interesting work. I wasn't an engineer, but I did some of the same things. I solved problems. I figured out what went wrong and came up with ways to fix it." After ten years in telecommunications, John's personal life necessitated that he move near the university. He explained, "I wanted to be a mechanical engineer, and I needed to move close to school anyway. They [the university] gave me a scholarship, so it was a no brainer."

Figure 8. John's journey map.

John moved within ten minutes of the university and enrolled into the mechanical engineering program. "Mechanical parts design was really where I wanted to be so the mechanical [engineering] program was a good fit," he said.

John met with his engineering advisor where he had a very positive experience. "She laid it all out there. She was awesome. She explained that it was not going to be easy…and I figured that. I walked out with a four-year plan," he remarked. John enrolled in physics, chemistry, a computer aided design class called solid edge. As he said,

> I could handle the physics and chemistry, but that class [solid edge] alone was the straw that broke the camel's back. I suspected that class was supposed to be a

> weed out class. My professor later confirmed that. At the end of the course he said that it wasn't his job to teach the software. It was his job to make us frustrated and mad. I don't get how a professor can do that.

John realized that he was "frustrated and mad" after his experience with the solid works class. He transferred out of engineering into business the following semester. "It was a brick wall and there was no way for me to make it," he said.

John advised the engineering college to "… make it possible [to graduate] or don't accept me [into the engineering program]". To future engineering students, he recommended, "…don't bother [with engineering] unless you fully understand what you are getting into."

Charles

"Basically forever I have always enjoyed math and science," said Charles when he was asked about his original draw to engineering. His father is an electrical engineer, two brothers are physicists, and another brother is a math educator. Charles had been around math and science his whole life. Originally, Charles felt his calling was to be a teacher as illustrated in Figure 9. Feedback from family and friends discouraged him from teaching because "teachers don't make much money." Between his junior and senior years of high school, Charles attended a summer program which was intended to inform high school students of some of the opportunities available for engineering students. Charles thought the program was very fun, and he was convinced to enroll in the engineering college. He had not decided which branch of engineering to pursue, so he majored in general engineering.

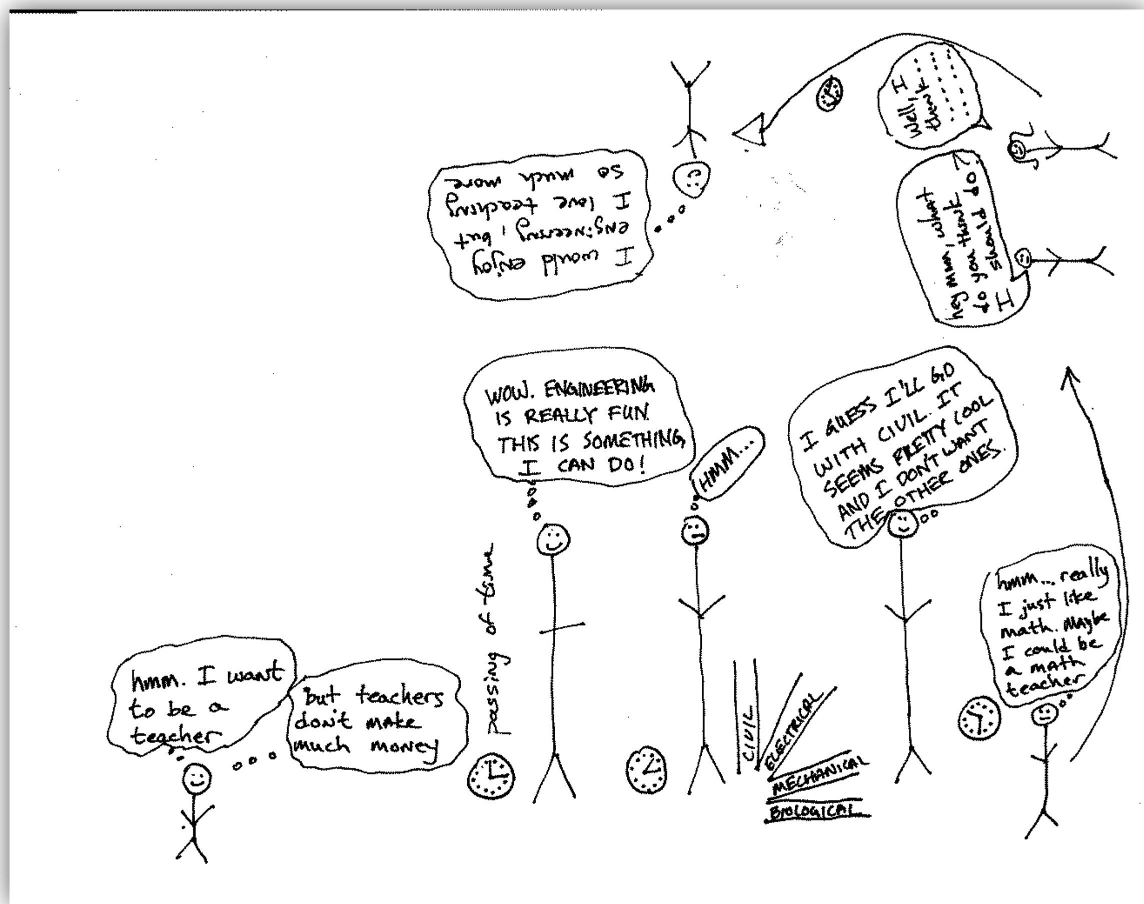

Figure 9. Charles' journey map.

Charles had taken and passed the AP Calculus test, so he was able to enroll in Calculus II his first semester. Describing his experience, he said,

> I had to rely on the book because the teacher mumbled a lot. He seemed like he knew the math but couldn't teach it. He seemed like the typical bad math teacher…like he was on the board doing the math for himself and we just happened to be in the room.

Charles quickly "learned the drill" of learning the material in Calculus II without relying on the instructor for help. He would attend the lectures to find out what the homework was for the week. He then went to the math tutoring center in the university's student center. He explained, “I wouldn’t talk to the tutors. They had the answer manuals there so I would start with the answer and work the homework backwards.” He earned an A in the course. “I feel like I learned a lot, but not because of the teacher.

The following semester Charles had Calculus III. “I had a good teacher, but she was really hard to understand. The teaching assistants were good, though, and they also had SI [supplemental instruction] which helped.” Charles had not decided on an engineering major. “I was planning on going on a mission [a two year Church service mission] after the first year of school, so I thought I would just wait to decide [on a major] when I got back.” Charles relayed an experience talking to his roommate about picking an engineering major. He said, “My roommate found a list of things each type of engineer did. I listened to all of them and, although I thought some of them sounded fun, there wasn’t anything I really felt passionate about.”

Charles took a two year leave of absence from school for Church service. When he came back to school he had still not decided which, if any, engineering major to pursue. “I kept procrastinating my decision,” he explained. He enrolled in general education classes including psychology and philosophy. He enjoyed the psychology course and termed psychology his, “...mistress major. I really like it but I won’t ever commit to it.” He decided he would pick an engineering major and pick up a full course load the following semester. He met with the engineering advisors who he found “very helpful”, and decided on civil engineering. “The counselor helped me put together a basic plan that showed I had three years left…so, four and one half years total,” he said. Charles signed up for several core civil engineering classes including computer programming. A few days later, he withdrew from all but one course and changed his major to math education. He said,

> I am not a computer guy. With my background I didn't really have trouble with classes, but computer programming was hard. I withdrew before a W would show up on my transcript. I had four days to pick a new major. Since I always loved math and I wanted to be a teacher, I chose math education.

Charles set up an appointment with an advisor from the math department. He also spoke with his mother, and elementary school teacher, to get her opinion. He said, "My mom was very supportive and excited [about my switch to math education]. She said I had a great personality to be a teacher." Although Charles did have some regrets about leaving engineering, he said, "I pictured myself in the future as an engineer, and I think I would have regretted not being a teacher."

Charles' advice to the engineering college was to, "explain to the [summer engineering introductory course] people that engineering is fun but really hard. I would have really enjoyed a class that explained the different kind of engineers… it would have helped me stay [in engineering] or make the decision [to switch out of engineering] sooner. To future students, his only advice was, "If you like it, go for it."

Jim

Jim thought his home school background left him, in some ways, unprepared for the decisions he was compelled to make in college. He explained, "I skipped middle school and my high school was more like a correspondence course, so I didn't have too much social interaction." Jim had given "no thought to engineering" until it was time for him to pick a major. He said, “I felt like I really wanted to do everything. But, I know I can’t do that so I chose computer engineering because I like video games and programming.” Jim’s journey map, Figure 10, illustrates several options he chose from in picking a major. He saw computer engineering as a way to, “…change others’ ideas and make them better.” Jim admitted, however, that he wasn’t really sure what exactly computer engineers did when he chose this field of study. Jim enrolled in computer engineering, but had several math courses to make up since he came to college without any AP or college credit classes. “I started Math 1010 [an introductory level math class] and I was doing homework in that class alone for up to six hours per day,” he said. Still feeling “disoriented” in his new college environment, Jim began to understand the level of commitment required to be an engineer. He earned a C- in Math 1010 which “scared” him a little. Still, he remained excited about the prospect of becoming a computer engineer. The following semester, Jim tackled trigonometry and college algebra. He earned a C in trigonometry and a B in college algebra. Jim felt he was doing better in math, and he had made more friends at the university and within the engineering college. “I was feeling better about engineering and my chances of making it, plus I wanted to be around people more,” he said. Jim stayed at the university and worked over the summer. He found time to participate in “extreme” outdoor activities with his friends. He worried about the time commitment he would have to make to pass his upcoming math courses.

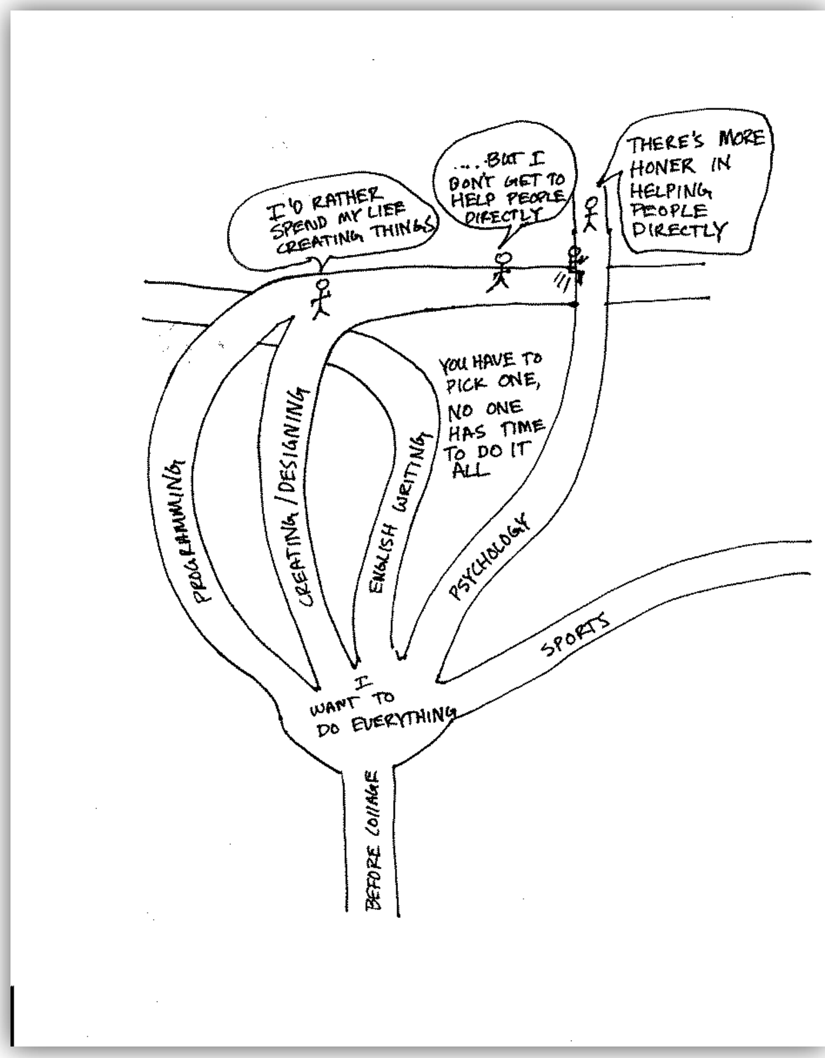

Figure 10. Jim’s journey map.

The following semester he enrolled in calculus I. As he said,

> I spent three fourths of my overall homework time on that one class and still got an F. I couldn’t understand the teacher because of his thick accent. Everybody in the class agreed that they were better off just learning the stuff themselves. I’m confident that if I took it [calculus I] again, I could pass now that I know how it works…I asked myself who I am going to become if I did it [retook the course]. I knew I would become more isolated.

Jim passed all of the rest of his classes that semester and determined that he was going to “find something else to study.” Jim took the next semester off because he “had no money and didn’t know what to do.” He explained, “I could justify getting some student loans if I knew what major they were going towards, but I didn’t.” Fearing the isolation Jim perceived that came with computer engineering, he decided that psychology would be a good way to “get involved with people more.” He transferred to psychology and expects to graduate in another two years.

When asked what advice he would have to future engineering students, Jim said, “Once you decide to do it [study engineering] jump on it ASAP.” He also recommended that students do the math series “somewhere else like a smaller college.” Finally he said there is a lot of information students can access for free to get them ready for the college experience. To the engineering college he advised, “The math instruction needs to be changed to fit more people. I think the speed is too fast. They also need to make sure the kids can understand the professors. Also, if they could find a way to help the kids link what they are learning to the real world, I think that would help.”

CHAPTER V

DISCUSSION

This chapter presents a detailed discussion of the results of this study. Discussion of the data collected is done in three parts: quantitative analysis, qualitative analysis, and comparison of quantitative and qualitative findings.

Quantitative Analysis

Research question one asked, “Which factors are associated with persistence in engineering?” This question sought to identify the statistically significant factors incoming freshmen possess that would predict persistence/nonpersistence in the engineering program at a major western research university. Institutional data were extracted from the university’s Banner database for 383 persisters and 383 nonpersisters. These data were compared using contingency tables based on chi-square or Fisher’s exact test analysis, and continuous factors were analyzed using a *t* test. Included in this institutional data were demographic descriptors (gender, age, residency status, marital status, and financial aid), secondary-level profile (high school GPA, ACT scores, and scholarship), and factors of local interest (lived on campus, and served an LDS mission). However, LDS mission was dropped because of reporting inconsistencies.The following section will analyze the results of quantitative analysis for each of the factors considered.

Are Female Students Less Likely Than Male Students to Persist?

Approximately 12% of undergraduate engineering students in this data set were female. An analysis comparing dropout rates for female and male students showed no significant difference. This suggests that although female students at a major western research university are in the minority, gender does not play a significant role in engineering student persistence. The engineering program has made effort to recruit and retain female students through female-focused groups and activities. This analysis shows that these efforts were successful from a perspective of student persistence but not necessarily in equalizing the number of males and females.

Is Student Age a Persistence Factor?

This question dealt with the effect of the student's age on persistence. Ideally, the age of each student at the moment the student decided to persist in or drop out engineering would be analyzed. These data were not available, but the institutional data did contain the student's birthdays and a date of expected graduation. Comparing these two variables, a new variable, "Age at Expected Graduation" was generated. Analysis showed that older students were much more likely to persist than younger students. Although the extent of the effect of age on persistence was surprising, it was not surprising that older students fared better than younger students. Possible explanations that older students were more likely to persist include a deeper understanding of the engineering profession, more fully developed study habits, and a more mature self-concept although variables such as these were not explored.

Is Student Residency Status a Persistence Factor?

The institutional data labeled each student a resident of the state in which a major western research university was located, a nonresident, or an international student. Analysis showed that nonresident students were more likely to drop out of engineering than resident students. Further, analysis showed that international students were much more likely to persist than either of the other groups. Nonresident students pay a much higher tuition than resident students at a major western research university. Students with financial concerns are less likely to persist. Additionally, since the majority of engineering students at a major western research university come from in-State, teaching methods and culture are more familiar for residents than nonresidents.

International students also pay a much higher tuition than resident students, but this tuition is often subsidized by the students' country of origin. International students rarely work off campus and experience less competing priorities than their resident counterparts. This, of course, does not discount the tremendous language and cultural barriers international students must overcome. The fact that international students persist at such a high rate is a testament to not only the tenacity of the international students, but also to the programs administered by a major western research university to integrate international students. Determining reasons for higher rates of persistence for international students would require additional research.

Are Students with Higher High School GPAs, ACT Math Scores, and ACT Composite Scores More Likely To Persist?

As expected, students with higher scores in high school are more likely to persist in engineering. It is reasonable that students with higher marks would fare better in navigating though the tests and assignments necessary to progress in engineering. It was unexpected, however how high the scores for both groups were. The mean high school GPA score of the nonpersisting group was 3.58. The persisting group had a mean GPA of 3.67. The difference was shown to be statistically significant. On a scale of 0 to 4.0, the mean GPA of both groups was very high. Similarly, the mean ACT Math and ACT Comp scores for both groups were higher than 26 and 25, respectively. These data suggest that the requirements for incoming freshmen are already lofty. The engineering college faces the often competing priorities of student recruiting and persistence. Raising the minimum test scores and GPA requirements for incoming freshmen may increase persistence of those students who can still make it into the program, but the pool of incoming freshmen may be smaller, resulting in no real increase of engineering graduates. Additional research would be required to determine the impact of raising entrance requirements at a major western research university.

Are Students with Scholarships More Likely to Persist?

Analysis of contingency tables showed that students with scholarships were no more likely to persist in engineering than students without scholarships. It should be noted, however, that the institutional data did not specify when students received scholarships, the amount or type of the scholarship, and if that scholarship had been maintained. Without this additional information, it is difficult to dismiss scholarships as a factor predictive of persistence in engineering. Two factors would lead the researcher to believe that scholarships are, in fact, predictive of persistence. The first is the tendency of students with financial concerns to drop out at a higher rate. Scholarships may add to the students' sense of financial wellbeing. Secondly, students with scholarships normally perform better academically than students who do not have scholarships. It follows that higher-performing students would be more likely to persist.

Are Students Who Have Received Financial Aid More Likely to Persist?

Students who have received financial aid are more likely to persist than those who did not. Similar to students with scholarships, a possible explanation of this finding is the effect financial wellbeing can have on persistence. Students who are comfortable in their financial situation are more likely to persist. The institutional data used for this analysis did not distinguish between grants and loans. Further study would be necessary to understand the effect that long term debt would have on students' short term sense of financial status.

Are Students Who Have Lived On Campus More Likely to Persist?

The analysis found no statistically significant difference in persistence based on students living on-campus. One possible explanation for this is the tendency for students to move often at a major western research university. The institutional data indicated if a student had ever lived on campus, but did not indicate where the student may have lived at the point in time a decision on persistence in engineering was made.

Are Married Students More Likely To Persist?

Analysis of the institutional data indicated married students are more likely to persist than single students. Possible reasons for the relative success of married students when compared with single students may include projected age at graduation, spousal support, and increased financial stability. The institution data did not indicate how long the students had been married, so additional research would be required to narrow down why married students outperformed their single counterparts.

Qualitative Analysis

Through careful analysis of participants' journey maps and the stories they told about them, major themes of individual and institutional factors contributing to their decision to leave the engineering program emerged. These findings are similar to what Tinto (1975) and other scholars in engineering attrition and persistence literature have found. Several other themes also emerged that are not well documented in the literature. These include a strong sense of loss and failure among participants and their easy transition to new fields of study. Finally, analysis of these findings suggests that students deal with a confluence of institutional and individual factors that are not easily isolated from one another.

Individual Factors

All of the participants mentioned feeling that they did not belong in the engineering program. As Tinto (1975) described, they all failed to achieve “social integration” (p. 92) in the program and the profession. In addition, as Seymour and Hewitt (1997) suggested, they seemed to show disinterest in and disappointment with engineering. Several of the participants lost their standing within the engineering culture because of their academic performance, particularly during their second year, and never regained a feeling of belonging. Their first failure in an engineering prerequisite course led to lowered effort and additional failures. Tseng et al. (2011) found this decrease in motivation and academic performance in the second year to be common among nonpersisting engineering students. Some participants were disappointed with engineering and came to the conclusion that substatial effort and money were “wasted.” This aligns with Tyson’s (2012) findings that many nonpersisters determine that the effort and money they spend on their studies are not worth the effort. Each of the other participants expressed a failure to fully integrate into the engineering culture for various reasons. Reasons for this included having few friends within engineering, lacking a mentor or adequate advising, or seeking help outside of the engineering department when they began to struggle.

Also common for all ten participants was the feeling of being overwhelmed by material and pace of their engineering education. A general disappointment in the difference between the participants’ perception of the engineering program and reality was also a common theme.

Institutional Factors

Perhaps the most common institutional factor mentioned by participants and supported by the attrition and persistence literature was the participants' feeling of unpreparedness for the rigors of the engineering program. Tinto (1975) and Koenig, et al., (2012) found that inadequate preparation and understanding led to student failure in fundamental engineering courses. Failure, in turn, led to students' diminished confidence in their abilities to succeed, as well as to higher attrition rates. Each of this study's participants specifically mentioned feeling unprepared for the commitments expected of them to succeed in the engineering program. Seven of the ten participants explained that inadequate preparation was, in their estimation, a contributing factor in their decision to leave engineering, despite the fact that all participants reported receiving high grades in high school. This fact confirms Croft and Grove's (2006) finding that good grades in high school do not necessarily translate into higher persistence in engineering.

Poor quality of instruction and mentoring was a common theme in the literature (Hurtado et al., 2010; Prieto et al., 2009; Tyson, 2012). Six of the ten participants mentioned poor instruction as a factor contributing to their decision to leave. Four of the participants reported positive relationships with at least one of their professors and appreciated the efforts others made to mentor them. Six participants were disappointed with their experience with the engineering advising. Their experience is similar to that reported in Haag et al. (2007) and McCuen et al. (2009), who observed that nonpersisters were dissatisfied with engineering advising and thought that advisers were too busy to help. Duncan and Zeng (2005) found that an unwelcoming culture in engineering colleges contributed to the students' decision to leave. This sentiment was echoed by eight of the participants in this study. Several of the participants addressed the "weed-out" culture of the engineering college, mentioning feeling "discouraged instead of advised" by the engineering advisers. Quality advising is part of what Tinto (1975) termed "institutional commitment" (p. 95); he believed that a strong institutional commitment to student success was an important part of students' "social integration" (p. 95) and contributed to students' departure from or persistence within a program. Table 17 includes a summary of the factors cited by participants for leaving engineering and their references in the literature. As can be seen in Table 15, several of the factors that have been studied in the literature were mentioned by one or more of this study's participants.

Issues Not Examined in the Literature

Through the face-to-face interviews and the journey-mapping activity, the former engineering students in this study revealed issues not previously examined in the engineering persistence and dropout literature, namely, the sense of loss and failure they experienced in leaving engineering, the remarkable ease with which they transitioned into other majors, and the confluence of institutional and individual factors that led to their departure. These findings result from the qualitative, narrative nature of this study and shed new light on some aspects of engineering education.

Table 15

Comparison of Factors Cited by Participants to the Literature

Reasons for leaving	Participants who stated this was a factor	Reference in literature
Individual factors		
Failure to integrate into engineering culture	Bob, Jenny, Zach, Karl, Abe, Bill, Scott, John, Charles, Jim	Tinto (1975)
Disappointed	Bob, Jenny, Zach, Karl, Bill, John, Charles, Jim	Seymour & Hewitt (1997)
Overwhelmed	Bob, Jenny, Zach, Karl, Abe, Bill, Scott, John, Charles, Jim	Seymour & Hewitt (1997)
Institutional factors		
Inadequate high school preparation	Bob, Jenny, Karl, Abe, Bill, Scott, Jim	Croft & Grove (2006); Tinto (1975)
Loss of motivation to study due to program rigor	Bob, Jenny, Zach, Karl, Bill Scott, Jim	Tseng et al. (2011)
Poor teaching/mentoring	Jenny, Bill, Scott, John, Charles, Jim	Marra et al. (2012)
Inadequate advising	Bob, Jenny, Zach, Karl, Bill, Jim	Prieto et al. (2009)
Unwelcoming culture of engineering college	Bob, Jenny, Zach, Karl, Bill, Scott, John, Jim	Duncan & Zeng (2005); Tinto (1975)
Financial pressures	Zach, Bill, Jim	Cabrera & Nora (1993)
Poor academic performance	Bob, Jenny, Zach, Karl, Abe, Bill, Scott, John, Charles, Jim	Seymour & Hewitt (1997); Tinto (1975)
Disinterested	Jenny, Charles	Seymour & Hewitt (1997)

Sense of loss and failure. Most striking among my observations while conducting this study was the deep level of emotion the participants expressed while describing their experience leaving engineering. Participants grew visibly emotional—some were even moved to tears. I asked participants if they felt they had let anyone down with their decision to leave. All felt they had let themselves down most of all. Most of the participants left the engineering program about one year before their interviews; some still harbored bitter feelings and strong emotions toward the engineering college. Many of the participants admitted, however, that the ultimate responsibility for their failure was their own. I mention the intense feelings of the participants to emphasize the tremendous emotional effect they experienced in leaving engineering. I can easily recall the fear and stress in my own undergraduate experience after poor performance on an exam or assignment. These intense emotions made me reconsider the group of 18 students I initially invited to join this study. All had left engineering within the past one or two months and all declined to speak with me. I imagine their feelings were still too raw; they likely were not ready to talk about their experiences.

Although study participants came into the engineering program from varying backgrounds, all expressed their respect for the engineering profession and their desire to become engineers. Most had studied engineering at the university for over a year and some mentioned referring to themselves as “an engineer.” In short, they felt that they were members of the club. Leaving engineering meant being dismissed from the club and left participants with the difficult tasks of not only dealing with a time-consuming and expensive failure, but also deciding what to do next.

Easy transition to new field. As they transitioned out of engineering, participants felt like they had been rejected from their career of choice and needed to rechart their course. All participants struggled with the question of what to do next. None felt that the difficulty of coursework in any other major would be an obstacle for them. This leads to the next finding that is seldom addressed in the literature: At the time of the interviews, most of the participants were earning “straight As” in their new majors. Most spoke very highly of their new departments and mentioned feeling accepted and welcomed in their new pursuits. Although many of the participants expressed some regret that they were not joining the engineering profession, all felt relieved to have escaped the pressures they still associated with engineering. Research on how engineering dropouts fare in other majors and on their impact on the rest of the university may add interesting insights to the research about engineering persistence.

Confluence of individual and institutional factors. This study reveals many of the institutional and individual factors that affect the persistence of engineering students described by Tinto (1975). Most participants dealt with the individual challenges of confidence and time management and faced the institutional challenges of difficult coursework and poor advising. Perhaps the key to understanding why participants left engineering is in examining the confluence of institutional and individual factors. Tinto wrote of the need for balance between institutional and individual domains and emphasized that “it is the individual’s integration into the academic and social systems of the college that most directly relates to his continuance in that college” (p. 96). Integrating into the social realm of the university but failing to integrate academically, and vice versa, puts a student’s university success at risk. The participants in this study showed imbalance in their integration into the academic and social spheres of the engineering program; this imbalance contributed to their decision to leave.

Seven of the ten participants felt unprepared for the undergraduate engineering experience. Many admitted to having only a vague concept of the engineering profession when they entered the undergraduate program. Although the university has limited control over the background and preparation of incoming freshmen, many of the participants mentioned the need for someone to “tell it to [them] straight” as soon as possible. Misunderstandings of the engineering profession and the efforts it takes to become an engineer are due to a combination of institutional and individual failings. An Introduction to Engineering course for incoming first-year students may improve undergraduates’ understanding and commitment to engineering; an introductory course also might motivate some students to leave engineering sooner, saving them time, money, and emotional turmoil (Bao et al., 2012).

The negative experiences participants had with the engineering advisers are among the institutional problems found in the literature. The matter of advising is another area where institutional and individual factors converge. Six of the ten participants expressed strong feelings about the callousness of the advising department, but many also admitted to seeking out its services too late. Some participants had already exceeded the engineering college’s allowable number of failures before contacting the advising department. Clearly, earlier intervention in students’ planning efforts by advisers is warranted. Earlier and increased involvement of advisers may also help change the students’ perceptions of a weed-out culture in the engineering college. But with more than 200 freshmen entering the engineering program each year, offering quality advising to this vulnerable group may require increases in staffing of the engineering advisers.

In summary, a better understanding of the emotional commitment students have to engineering, the easy transition departing students make to other fields, and the confluence of individual and institutional factors affecting student persistence may help the university implement positive interventions through its advisers, instructors, and tutors.

Discussion of Quantitative and Qualitative Commonalities

The quantitative portion of this study identified four major factors in which the persisting group varied significantly from the nonpersisting group. These factors were student projected age at graduation, high school and ACT test performance, receipt of financial aid, and marital status. Major findings of the qualitative portion of the study included six general categories the nonpersisting participants indicated were factors in their dropping out of engineering. These categories included failure to integrate and feeling unwelcome in the engineering culture, disappointment with engineering including the teaching and advising offered, poor academic performance due to feeling overwhelmed with the program rigor, inadequate high school preparation, financial pressures, and loss of interest in the engineering profession. This section includes a mixed-methodological analysis of the overlap of the quantitative and qualitative findings, and discusses the implications of their confluence. A summary is presented in Table 16. In short, qualitative findings are discussed in an effort to complement the quantitative findings.

Table 16

Summary of Mixed-Methodological Analysis

Results from quantitative inquiry – students were less likely to persist if they:	Complementary results from qualitative analysis
Had a younger projected age at graduation	1. Failure to integrate 2. Disappointment with engineering 3. Poor academic performance 4. Inadequate high school preparation 5. Financial pressures 6. Loss of interest
Had lower high school and act test performance	1. Failure to integrate 3. Poor academic performance 4. Inadequate high school preparation
Received no financial aid	1. Failure to integrate 3. Poor academic performance 5. Financial pressures
Were unmarried	1. Failure to integrate 2. Disappointment with engineering 5. Financial pressures 6. Loss of interest

Why Are Older Students More Successful in Engineering?

Older students may have advantages over their younger counterparts in each of the six categories identified in the qualitative portion of the study. Because of additional life experience, it is believed by the researcher that older students tend to integrate more easily into the culture of engineering. Maturity may also help with acceptance of teaching and mentoring offered by the engineering program. Older students are more experienced in financial management, and dealing with the pressures of the rigorous and demanding engineering program. Because of a greater separation from high school than their younger colleagues, older students may have made up for any inadequate high school preparation. Finally, older students may be more familiar with the engineering profession, which would lead to a more informed decision to pursue engineering.

Why Are High Scores from High School and ACT Tests Predictive of Persistence?

High school and test performance are a manifestation of the student's ability to gather and retain knowledge. In addition, high school grades and test scores are also indicative of the students understanding of the nuances and culture of the educational system in which the student is participating (Tyson, Lee, Borman, Hansen, 2007). For example, an ill-prepared student may outscore a well-prepared student on an examination if the ill-prepared student is more knowledgeable about how to take the examination. The well-prepared student may spend too much time on one question; fail to read through the entire question, etc. Thus, test performance may not exclusively be a measure of the student's knowledge in the test's subject, but may also measure the student's ability to adapt and find pathways to success. It follows that students with high grades and high scores on standard tests tend to better able to adapt and succeed than their counterparts with lower scores. This is not necessarily a reflection on the intelligence of the student, but rather a measure of the student's ability to succeed in new, often difficult environments.

Students with higher grades and test scores have proven more resilient and adaptable which would give them an advantage over their counterparts in three of the qualitative categories; namely failure to integrate, poor academic performance, and inadequate high school preparation (Tyson et al., 2007). Because students with higher grades test scores may be more adaptable to new environments, it would follow that integration into the new culture of the engineering program would be easier for them. Higher performing students may be more practiced in identifying pathways to success when confronted with difficult assignments, and would, therefore, be less likely to be overwhelmed by the engineering program's rigor. Finally, higher performing students in high school may be better prepared for college not only academically, but also in motivation to succeed.

Why Is Receiving Financial Aid Predictive of Persistence?

Analysis of the institutional data indicated that students who received financial aid were more likely to persist than those who did not. Four of the qualitative findings may help explain why those with financial aid were more successful. Although the information gained from the institutional data was limited, it was assumed that students without financial aid were more concerned with making financial ends meet than those with financial aid (Whalen & Shelley, 2010). Students without financial aid may have been more likely to seek part or full time employment. This employment may have implications on the student's ability to integrate into the engineering culture, and the student's performance in her classes. Succumbing to financial pressures may also increase students' rate of attrition from the program.

Why Is Marital Status Predictive of Persistence?

Analysis of the institutional data showed that married students outperformed their single counterparts on persistence in engineering. The four qualitative factors of failure to integrate, disappointment with the program, financial pressures, and disinterest in engineering may help explain this finding. There exists little literature on the effect of marriage on persistence, and additional research into this topic is warranted.. Because married students have a partner outside of the engineering sphere, their need to integrate into the engineering culture may be lessened. Similarly, their need for quality advising may also be lower than unmarried, younger students. Financial pressures may be lessened due to some sharing of the financial burden with spouses, along with a more favorable tax treatment. Finally, sharing goals and planning with a spouse may help married students to be more informed when making the decision to pursue engineering.

CHAPTER VI

CONCLUSIONS AND RECOMMENDATIONS

This chapter includes a detailed discussion of the conclusions of this study, outlines possible implications of the findings, and provides recommendations for a major western research university and similar institutions for interventions to increase persistence of engineering undergraduate students. Future research efforts are also suggested that could further expand the body of knowledge surrounding persistence of engineering undergraduates.

Conclusions

This mixed-methodological research combined an analysis of institutional data to determine predictive factors for persistence/nonpersistence in engineering with the important dimensions of narrative and lived experiences to understanding the low rate of student persistence in engineering. Data analysis identified four factors predictive of persistence at a major western research university. These factors were student projected age at graduation, high school and ACT test performance, receipt of financial aid, and marital status. Participants in the qualitative portion of this study painted complex pictures of the reasons they left engineering. Six categories were identified from the qualitative research common among the participants. These categories included failure to integrate and feeling unwelcome in the engineering culture, disappointment with engineering including the teaching and advising offered, poor academic performance due to feeling overwhelmed with the program rigor, inadequate high school preparation, financial pressures, and loss of interest in the engineering profession. The intersection of the quantitative and qualitative sections of this research provided a deeper understanding of persistence than either method alone could have provided.

The quantitative portion of the study was designed to answer which factors could be identified as significant predictors of persistence. These factors could be used as admittance criteria to admit only those students with a higher likelihood to succeed. The qualitative portion of the research provided a rich understanding of ten students' experience leaving engineering. This information may help tailor interventions from a major western research university to help increase student persistence. From the mixed-methodological analysis of the results, the conclusion can be drawn that secure students are more likely to succeed than insecure students. Stability is necessary in three areas. These include financial security, social acceptance, and academic security. Expressed another way, successful students maintain a better balance of stability in these three areas than unsuccessful students. The engineering college has limited, but important influence on the financial, social, and academic security of engineering undergraduates. The engineering college, in conjunction with a major western research university can implement programs, and highlight existing programs, to assist engineering undergraduates with the financial burdens associated with their education. To enhance a feeling of social acceptance and belonging for incoming engineering students, this research suggests that outreach from the engineering college to students during their vulnerable first and second years in engineering may have a positive effect upon persistence. The engineering college can contribute to students' sense of good academic standing by ensuring quality teaching, mentoring and advising.

More drastic steps the engineering college could take to improve persistence include adjusting entrance criteria to increase the chances of success for students admitted into the engineering program, realigning the college's persistence goals with the curriculum and advising offered to the students, and intervening earlier with struggling students. It is also apparent that orienting incoming students to the demands and procedures of the engineering program would be beneficial toward improved persistence. Providing alternate degree options for students who are failing in traditional engineering programs, while retaining these students in the engineering college, may enhance persistence.

Recommendations for a Major Western Research University for Increased Persistence

It can be argued that a major western research university does not have a problem with persistence. A major western research university has a long tradition of producing successful, competent engineers. This reputation may be due, in part, to the high rate of attrition of its engineering students. Low persistence may be a reflection of the high and uncompromising standards of the engineering college. The perception of nearly all of the unsuccessful students interviewed in the qualitative portion of this study was that the engineering program seems geared around weeding out unqualified students. If the engineering college is, in fact, content with graduating a few, select engineers, perhaps the entrance requirements should be adjusted to lower the number of students admitted and increase admitted students chances for success. Increasing the contact time between students and advisers, especially in the first few semesters, may also help new students integrate better and lead to higher persistence.

If retaining more students in the engineering college under the current entrance requirements is the goal, a major western research university should consider the provision of an alternate path for those students unable to meet the demanding requirements of the current program. A nonengineering license track such as an engineering technician or engineering sales degree could provide an option for students who are currently leaving the engineering program altogether.

Generalizability of the Findings

As shown in the analysis section of this study, many of the findings match well with the literature on persistence of engineering students. It follows that the findings and recommendations of this study may be generalizable to many engineering programs suffering from low persistence of undergraduate students. Although each engineering program has its own unique challenges, findings and interventions suggested by this study may provide a good starting point for increased persistence.

Suggestions for Future Research

Because the institutional data was limited, the scope of the finding analysis of the data provided was also limited. Interesting questions about the findings emerged that require further investigation and may warrant their own study. These include inquiry into why older students outperform their younger peers, what types of financial aid are most effective in increasing student persistence, and why married students persist at a higher rate than single students. On the qualitative portion of the study inquiry into the sense of loss and failure experienced by nonpersisting students and nonpersisting students experience after transferring into other majors is warranted. Finally, additional research into the confluence of institutional and individual factors in student persistence at each university location is needed to develop successful interventions.

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APPENDICES

Appendix A

IRB Approval

Matthew Meyer, PE

From:	noreply@usu.edu
Sent:	Friday, January 24, 2014 9:33 AM
To:	ning.fang@usu.edu; kristina.glaittli@usu.edu; dean.adams@usu.edu; matt@provident-energy.com
Subject:	Approval letter from USU IRB

UtahState University
OFFICE OF RESEARCH AND GRADUATE STUDIES

Institutional Review Board

USU Assurance: FWA#00003308

Exemption #2

Full Accreditation

Certificate of Exemption

FROM:	Melanie Domenech Rodriguez, IRB Chair True M. Rubal, IRB Administrator
To:	Ning Fang, Kristina Glaittli, Virgil Adams, Matthew Meyer
Date:	January 24, 2014
Protocol #:	5034
Title:	A Retention Factor Analysis For Engineering Undergraduates At Utah State University

The Institutional Review Board has determined that the above-referenced study is exempt from review under federal guidelines 45 CFR Part 46.101(b) category #2:

> Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (a) information obtained is recorded in such a manner that human subjects can be identified, directly or through the identifiers linked to the subjects: and (b) any disclosure of human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

This exemption is valid for three years from the date of this correspondence, after which the study will be closed. If the research will extend beyond three years, it is your responsibility as the Principal Investigator to notify the IRB before the study's expiration date and submit a new application to continue the research. Research activities that continue beyond the expiration date without new certification of exempt status will be in violation of those federal guidelines which permit the exempt status.

As part of the IRB's quality assurance procedures, this research may be randomly selected for continuing review during the three year period of exemption. If so, you will receive a request for completion of a Protocol Status Report during the month of the anniversary date of this certification.

In all cases, it is your responsibility to notify the IRB prior to making any changes to the study by submitting an Amendment/Modification request. This will document whether or not the study still meets the requirements for exempt status under federal regulations.

Upon receipt of this memo, you may begin your research. If you have questions, please call the IRB office at (435) 797-1821 or email to irb@usu.edu.

The IRB wishes you success with your research.

4460 Old Main Hill   Logan, UT 84322-4460   PH: (435) 797-1821   Fax: (435) 797-3769   WEB: irb.usu.edu   EMAIL: irb@usu.edu

Appendix B

Institutional Data Sample

SAMPLE NUMBER	1=SUCCESS, 2=UNSUCCESS	MAJR	ADMIT_TERM	EXP_GRAD_DATE	GENDER	MRTL_STATUS	BIRTHDAY	RESIDENCY	TRAN_SCHOOL	HS_GPA	ACT_MATH	ACT_COMP	SOAR_PARTICIPANT	SCHOLARSHIP	FIN_AID	HOUSING	LDS_MISSION_LOA
1	1	COSC	201340	20-Dec-19	M	M: Married	22-Jul-73	R	UTAH STATE UNIVERSITY				N	N	Y	N	N
2	1	COSC	201340	20-Dec-19	M	M: Married	10-Nov-78	R	SALT LAKE COMMUNITY COLLEGE, SNOW COLLEGE, TOTAL COLLEGE CREDITS/GPA				N	N	Y	N	N
3	1	ELEN	201340	20-Dec-19	M	M: Married	24-Dec-79	R	SALT LAKE COMMUNITY COLLEGE, UTAH STATE UNIVERSITY				N	Y	Y	N	N
4	1	CIEN	201340	20-Dec-19	M	S: Single	28-Jan-82	R	SANTA BARBARA CITY COLLEGE, SOUTHERN UTAH UNIVERSITY, TOTAL COLLEGE CREDITS/GPA, VENTURA COLLEGE				N	N	Y	Y	N
5	1	ENVE	201340	20-Dec-19	M	S: Single	18-Mar-84	N	NEWBERRY COLLEGE				N	N	Y	N	N
6	1	COSC	201340	20-Dec-19	M	S: Single	27-Apr-85	R	MCKENDREE COLLEGE, SALT LAKE COMMUNITY COLLEGE, SOUTHWESTERN ILLINOIS COLLEGE, TOTAL COLLEGE CREDITS/GPA				N	N	N	N	N
7	1	COSC	201420	20-Dec-19	M	M: Married	7-Sep-85	R	UTAH STATE UNIVERSITY	4	27	26	N	N	N	N	N
8	1	ELEN	200920	20-Dec-19	M	M: Married	2-Apr-86	R	SNOW COLLEGE, UTAH STATE UNIVERSITY				N	Y	Y	N	N
9	1	COSC	201320	20-Dec-19	M	S: Single	28-Jul-86	R	UTAH STATE UNIVERSITY	2.94	25	22	N	Y	Y	Y	N
10	1	MEEN	201340	20-Dec-19	M	S: Single	12-Mar-87	R	UTAH STATE UNIVERSITY	3.96	29	28	N	Y	Y	N	Y
11	1	MEEN	201340	20-Dec-19	M	S: Single	15-Mar-87	N	GERMANNA CMTY COLLEGE				N	N	Y	N	N
12	1	GENG	201340	20-Dec-19	M	S: Single	11-Dec-87	R	UTAH VALLEY UNIVERSITY	2.957			N	N	N	N	N
13	1	CMPE	201340	20-Dec-19	M	M: Married	26-Jun-88	R	SALT LAKE COMMUNITY COLLEGE, TOTAL COLLEGE CREDITS/GPA, UNIVERSITY OF UTAH, WEBER STATE UNIVERSITY		26	28	N	N	Y	N	N
14	1	CIEN	201340	20-Dec-19	M	M: Married	27-Aug-88	R	COLLEGE OF EASTERN UTAH, SOUTHERN UTAH UNIVERSITY, TOTAL COLLEGE CREDITS/GPA	4	26	26	N	N	Y	N	N
15	1	MEEN	201340	20-Dec-19	M	S: Single	19-Sep-88	R	SALT LAKE COMMUNITY COLLEGE				N	N	Y	N	N
16	1	MEEN	200740	20-Dec-19	M	S: Single	17-Jan-89	R	UTAH STATE UNIVERSITY	3.809	28	28	N	Y	Y	N	Y
17	1	CMPE	201340	20-Dec-19	M	S: Single	25-Feb-89	R	SALT LAKE COMMUNITY COLLEGE, TOTAL COLLEGE CREDITS/GPA, UTAH STATE UNIVERSITY, WEBER STATE UNIVERSITY				N	N	Y	N	N
18	1	MEEN	201340	20-Dec-19	M	M: Married	27-Mar-89	R	TOTAL COLLEGE CREDITS/GPA, UTAH STATE UNIVERSITY, WEBER STATE UNIVERSITY	3.95	24	22	N	Y	Y	N	N
19	1	MEEN	201340	20-Dec-19	M	S: Single	11-Apr-89	R	SALT LAKE COMMUNITY COLLEGE, TOTAL COLLEGE CREDITS/GPA, UNIVERSITY OF UTAH, UTAH STATE UNIVERSITY	3.59	25	25	N	N	Y	N	N
20	1	GENG	201340	20-Dec-19	M	M: Married	27-May-89	R	DIXIE STATE COLLEGE, SNOW COLLEGE, TOTAL COLLEGE CREDITS/GPA, UTAH STATE UNIVERSITY	3.5			N	N	Y	N	N
21	1	ELEN	201040	20-Dec-19	M	M: Married	9-Aug-89	R	UTAH STATE UNIVERSITY	4	32	33	N	Y	N	N	N
22	1	ELEN	200840	20-Dec-19	M	S: Single	16-Dec-89	N	IDAHO STATE UNIVERSITY, UTAH STATE UNIVERSITY	4	36	33	N	Y	Y	N	Y
23	1	MEEN	201340	20-Dec-19	M	S: Single	25-Apr-90	R	AMARILLO COLLEGE, TOTAL COLLEGE CREDITS/GPA, UTAH STATE UNIVERSITY, UTAH VALLEY UNIVERSITY	3.8	25	29	N	N	N	Y	N
24	1	MEEN	201340	20-Dec-19	M	S: Single	15-Jun-90	R	SNOW COLLEGE, TOTAL COLLEGE CREDITS/GPA, UTAH VALLEY UNIVERSITY	3.67	25	21	N	Y	N	N	N
25	1	COSC	201420	20-Dec-19	F	S: Single	19-Jul-90	R	UTAH STATE UNIVERSITY	3.9	29	31	N	Y	N	Y	N
26	1	ELEN	200840	20-Dec-19	M	M: Married	8-Aug-90	R	UTAH STATE UNIVERSITY	4	27	27	N	Y	Y	N	Y

Appendix C

Initial Interview Questions

Initial Interview Questions.

1. What factors led you to leave engineering?
2. How did your pre-university experience prepare you for the engineering program?
3. If you could go back and change anything, what would you do differently?
4. What would you suggest to future engineering undergraduates to increase retention?
5. What changes would you suggest the engineering program make to increase retention?

Appendix D

Copyright Permission Letter

JOURNAL OF ENGINEERING EDUCATION
The research journal for engineering education • Published by the American Society for Engineering Education

Michael C. Loui, Editor • Professor Emeritus of Electrical and Computer Engineering
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March 30, 2015

Mr. Matthew Meyer
Provident Energy
matt@provident-energy.com

Dear Mr. Meyer:

I am responding to your request for permission to reproduce substantial portions of your article "Engineering Dropouts: A Qualitative Examination of Why Undergraduates Leave Engineering," by Matthew Meyer and Sherry Marx, in the October 2014 issue of *Journal of Engineering Education* (JEE), published by the American Society for Engineering Education (ASEE).

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Please accept my best wishes on the completion of your doctorate at Utah State University.

Yours truly,

Michael C. Loui

Michael C. Loui
Editor

CURRICULUM VITAE

MATTHEW MEYER

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Ogden, UT 84414

EDUCATION & LICENSURE

Utah State University, Logan, UT
PhD Engineering Education
2015
M.S. Civil and Environmental Engineering – Water and Wastewater Treatment Emphasis, Graduated 1996
B.S. Civil and Environmental Engineering
Graduated 1995

Licensed as a *Professional Engineer* in Utah and California

Master Trainer Certification with the National Center for Construction Education and Research (NCCER)

TEACHING EXPERIENCE

- *Instructor, Salt Lake Community College,* State Energy Sector Partnership (SESP) Grant, *Sandy, UT, 2010-P*
- As part of U.S. Department of Labor and Utah Department of Workforce Services training grant, developed curriculum and taught building science, green building, building and the environment, LEED building, weatherization, and green retrofitting.
- Instructor of Green Retrofit and HERS training courses in both traditional and online format. This was offered as an add-on to the building science class. Students were trained both in the classroom and the field to gain a Home Energy Rating (HERS) Certificate that the student can use to start a business. The field training involved meeting with groups of students at residential building sites and conducting training in field testing techniques.
- Presented at Utah Building Energy Efficiency Strategies (UBEES) Morningside Training program. Instructed builders, inspectors, and code officials on 2006 IECC Code Compliance using the Performance Method.
- Recorded builder continuing education modules as part of Salt Lake Community College's remote builder education series.
- Took lead role in PNNL 2006 IECC Code Compliance Study for Utah including presentation of results to State of Utah Office of Energy Development.

- Achieved Master Trainer certification through the National Center for Construction Education and Research (NCCER).

RESEARCH EXPERIENCE

- ***Doctoral Graduate Student, Engineering Education Department, Utah State University,*** *Logan, UT, 2012-P.*
- Current doctoral research includes qualitative and quantitative studies of how engineers learn, how to improve retention of engineering undergraduates, and how to improve the quality of teaching in engineering.
- Meyer, M., Marx, S., Engineering Dropouts: A Qualitative Examination of Why Undergraduates Leave Engineering, *Journal of Engineering Education*. A qualitative study of students' reasons for leaving the undergraduate engineering program at Utah State University.
- ***Master's Graduate Student, Environmental Engineering College, Utah State University,*** *Logan, UT, 1995-6.*
- Master's thesis entitled, "Toluene Removal Using a Fluidized Bed Bioreactor."

PROFESSIONAL EXPERIENCE

- ***Engineering Design, Construction and Development,*** *Ogden, UT, 1996-P.*
- Managed energy efficient design, testing, and construction firm.
- Developed over 1,000,000 sf of commercial real estate space.
- Designed and entitled over 1800 residential building lots. Managed the construction of nearly 500 building lots.

AWARDS AND AFFILIATIONS

- Master Trainer Certification with the National Center for Construction Education and Research (NCCER)
- LEED Accredited Professional with a Building Design + Construction Specialty
- Award of excellence for level of participation in the Utah Home Performance program under USEPA's Energy Star program, 2012.
- Energy Champion award from Utah Clean Energy, 2012.
- Member of Utah Home Performance Partner Advisory Council.
- Member of IECC Uniform Building Code Commission Ad Hoc committee.
- Member of IECC Analysis Working Group Committee.
- Member of Wasatch Division of Utah Home Builder's Association.
