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FACTORS INFLUENCING ENGINEERING STUDENT PERSISTENCE: A TWO INSTITUTION STUDY

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by

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Abstract

The purpose of this study was to investigate the persistence factors of undergraduate engineering students and compare those factors at an R2 research university and a regional university. The study further investigated if these factors are different based on gender and race/ethnicity. This study used quantitative methodology to determine the significance of the differences in universities, genders, and races/ethnicities. Tinto's (1975, 1993) student departure theory, Bean's (1988, 2001) student departure model, Astin's student involvement and development theory, and a study by Marra et al. (2012) provided the theoretical framework for this study. Findings from the survey sample of 52 students revealed pre-college, college, and retention persistence factors and the differences for university type, gender, and race/ethnicity. Pre-college included academic factors and college included academic support strategies, involvement, institutional climate, social, and personal factors. Co-op and internship involvement impacted persistence the most for retention strategies. University type, gender, and race/ethnicity had significant persistence factors when analyzed. The results of this study found persistence factors for engineering students extend from pre-college through college and are dependent on university type, gender, and race/ethnicity.

Keywords: academic factors, attrition, engineering, gender factors, persistence, personal factors, race/ethnicity factors, social factors, student departure model, student departure theory, student involvement and development theory, retention

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Chapter I: Introduction

Higher education has researched and implemented programs to help increase retention rates. These initiatives occur in the general university setting with some institutions researching the need for specific programs. Although there has been an increase in retention programs the retention rates have stayed the same for some college programs.

Engineering has seen a decrease in the number of graduates due to factors including poor teaching and advising, difficult curriculum, and a feeling of not belonging in engineering (Charboneau, 2020). Researchers have studied factors that have contributed to students dropping out or changing majors with mixed results. Some universities have increased retention programs in their colleges of engineering with little effect on the retention rates. Between 40% and 50% of engineering students will drop out or change their major before they graduate (Charboneau, 2020). There has been an increase in the number of students enrolling in engineering schools, but retention remains the same. The increase in demand for engineers coupled with retention issues has created a shortage in the engineering field.

Statement of Problem

Students enter university engineering programs with excitement toward becoming an engineer. Over their first year, many students change this perception and decide to change majors or withdraw from the university altogether. Many factors have been identified in research as to why students decide not to persist in engineering. These persistence factors can be categorized into pre-college, college, social, and personal factors (Adelman, 2006; Braunstein et al., 2001; Conley, 2007; Hu, 2010; Hughes et al., 2019; Niu & Tienda, 2013; Robbins et al., 2004; Sternberg, 2013; Stewart et al., 2015; Terriault & Krivoshey, 2014; Titus, 2004; Veenstra, 2009; Walsh & Kurpius, 2015).

Most research on persistence factors looks at the university setting as a whole instead of identifying persistence factors in specific programs or colleges (Astin, 1999; Bean & Eaton, 2001; Elkins et al., 2000; Hu, 2011; Reason, 2009; Ryan, 2004; Sternberg, 2013; Stewart et al., 2015; Suhre et al., 2007; Therriault & Krivoshey, 2014; Tinto, 1993; Titus, 2004; Veenstra, 2009; Walsh & Kurpius, 2015). As retention issues become more prevalent, research is starting to look at specific college programs to identify persistence factors that may help in establishing retention programs (Bernold et al., 2007; Desai & Stefanek, 2017; Eris et al., 2010; French et al., 2005; Geisinger & Raj Raman, 2013; Godfrey et al., 2010; Hall et al., 2015; Lin, 2017; Meyer & Marx, 2014; Ohland et al., 2008; Santiago, 2013; Veenstra et al., 2009). There is some recent research on persistence factors contributing to lower retention in engineering with the most recent study looking at pre-college and college factors being 2012 (Marra et al., 2012). Researchers at different universities since that point have looked more closely to implement retention programs such as living-learning communities, freshman-level design and engineering exploration courses, math remediation, and mentor programs. Some colleges of engineering such as Mercer University and Oklahoma University have researched to see what factors contribute to engineering students persisting so they are better informed on recruitment and implementing proper retention programs (Burtner, 2004; Davis et al., 2012). These studies have contributed to retention programs, such as Oklahoma University College of Engineering offering freshman-level design courses which has seen an increase in retention (Davis et al., 2012).

Throughout the past few years, there have been a lot of changes for universities and students. Specifically, the change in students that has occurred since the COVID-19 pandemic has seen a shift in students changing to online learning, students commuting instead of living on campus, experiencing mental health problems, academic decline, and financial stress (Hu et al., 2022). Universities are also experiencing a decline in student enrollment and have a need for increased recruitment and retention (Hu et al., 2022). Engineering colleges are no exception to what students and universities have been experiencing since the pandemic with little research since the pandemic on what factors are now contributing to students persisting in engineering.

Engineering persistence research has primarily been focused on single institutions, as examples provided above with Mercer University, Oklahoma University, and the study by Mara et al. (2012). These single-institution studies do not address the differences in persistence between university types of R1 research, R2 research, and regional universities. R1 and R2 research universities are doctoral universities with high research that receive federal funding specifically for academic research (Basic classification, 2023). With the decline in the number of engineers graduating, there are more regional universities offering engineering as a major and being accredited which increases the need for persistence research at those universities. The differences among engineering programs could potentially influence student's persistence factors.

This gap in the literature of potential differences in persistence factors depending on university type, has caused little change in retention programs looking at new innovative ways to improve retention. As mentioned, persistence factors can be different at different universities with the need for research to compare factors at R1/R2 research universities compared to regional universities. An increase in the need for engineers has seen an increase in more regional universities being accredited to offer engineering as a major. There is a need to understand if persistence has changed since the pandemic and if there is a difference in the persistence factors at different universities so that retention programs can focus on the factors necessary to improve retention.

Purpose of Study

This study aims to investigate persistence factors for engineering students after their first year and compare those factors between an R2 research university and a regional university as well as if there are differences in persistence factors for genders and race/ethnicities. General college persistence factors have led to the development of retention programs to try and increase retention rates. Persistence factors identified can be categorized into pre-college, college, social, and personal factors. Pre-college factors have been shown to influence how prepared students are to enter college and be successful such as grade point average, SAT and ACT scores, AP scores, end-of-course exams, dual enrollment, and the intensity of high school curriculum (Reason, 2009; Terriault & Krivoshey, 2014). General college persistence factors have been identified in the literature as first-semester GPA, participation in remedial classes, completing a two-year degree before transferring to a four-year institution, and additional institution factors (Braunstein et al., 2001; Reason, 2009; Steward et al., 2015; Tinto, 1993). Social factors are the amount of social engagement or integration a student experiences with their peers and school faculty (Therriault & Krivoshey, 2014). Personal factors have been more difficult to research but some literature points to factors such as first-generation college students, family finances, self-efficacy, resilience, self-expectations, psychological issues, parent background, and gender/race (Dowd & Coury, 2006; Niu & Tienda, 2013; Robbins et al., 2004; Sternberg, 2013; Steward et al., 2015; Therriault & Krivoshey, 2014; Tinto, 1975).

Engineering persistence factors can be categorized similarly to general college persistence factors of pre-college, college academic, social, personal, and gender/race factors. While these factors can be categorized the same there are differences in the level of influence on these factors for engineering students. Pre-college influence is dependent on quantitative skills and the confidence in those skills along with high school GPA, SAT, and ACT scores, the intensity of high school academic preparation, mentors, and pre-engineering curriculum in their high school (Cole, 2013; Geisinger & Raj Raman, 2013; Hirsch et al., 2006; Suresh, 2007; Veenstra et al., 2009). College factors specific to engineering include the institutional and classroom climate, faculty interaction, GPA, and difficult curriculum (Daempfle, 2002; Hall et al., 2015; Marra et al., 2012; Meyer & Marx, 2014; Seymour & Hewitt, 1994). Social factors include balancing social life with a difficult engineering curriculum or time management (Kuley et al., 2015). Personal factors include self-efficacy, engineering identity, stress, lack of confidence, parents background, pressure, and finances (Fantz et al., 2011; Geisiner & Raj Raman, 2013; Mau, 2003). Engineering has typically been a white-male-dominated profession with research identifying minorities and females leaving at higher rates due to engineering identity (Geisinger & Raj Raman, 2013; Hughes et al., 2019).

This study investigates the pre-college, college, social, and personal persistence factors since the COVID-19 pandemic for engineering colleges. The research will focus on an R2 research university and a regional university to compare the similarities and differences since the increase of more regional universities offering engineering as a major. Since there has been a shift in universities and students since the pandemic it is important to understand if persistence factors have changed as well as if there are differences in persistence factors at different size universities. The goal of the study is to identify persistence factors among the different-sized universities, genders, and races/ethnicities to help institutions of higher education in their development of engineering recruitment and retention programs.

Theoretical Framework

This research is a quantitative casual comparison study using data from an R2 research university in a large urban city and a regional university in the western part of Kentucky. The study is built upon the early persistence theories of Tinto (1975, 1993), Bean (1988, 2001), and Astin (1999). Additionally, a study by Marra et al., (2012) helped to develop the groundwork for this study as it looked at a single institution and the factors contributing to persistence in engineering school instead of just general university persistence.

Tinto's (1975, 1993) theory of student departure identifies students' inability to integrate socially and academically as a reason for leaving college. His model is known as the student integration theory which identified academic failure as only 15% to 25% of the explanation of why students leave. While pre-college factors were identified in this model, Tinto stressed the importance of college integration as the influence on why students persist. This integration included on-campus living, separation from home, and faculty/student interactions (Tinto, 1993). The higher the level of social and academic integration, according to Tinto (1975, 1993), the more likely a student will persist.

Bean's (1988, 2001) student departure model developed from a critique of Tinto's student integration theory and further research in persistence. The student departure model added to Tinto's model by identifying self-efficacy, self-control, coping skills with learning, and motivation contributing to academic and social integration. Tinto's model did not look at psychological and environmental influence in the way Bean's student departure model did.

Astin's (1999) student involvement and development theory was based on a single institutional study focused on a behavioral model. Student involvement was the primary finding of Astin's study with physical and psychological energy a student puts forth as the primary reason a student will persist. If a student is more involved in and out of class, the more likely they will be successful in college and continue.

Engineering persistence has gained more attention recently due to the decrease in students being retained. Marra et al. (2012) researched factors that contribute to persistence in a single-institution study and found poor teaching, interactions with faculty, classroom climate, difficult curriculum, engineering identity, and low self-efficacy as primary reasons for students not to persist. This study by Marra et al. (2012) identified some factors similar to Tinto, Bean, and Astin but also found specific factors that contribute to students in engineering.

Research Questions

The research questions and hypotheses are:

1. What pre-college factors (academic, social, and personal) influence engineering school persistence as perceived by students? How do these differ in an R2 research university compared to a regional university?

    H1: Academic preparation will be the greatest influence on persistence and there will not be a significant difference between the research and regional universities.

2. What college factors (academic, social, and personal) influence engineering school persistence as perceived by students? How do these differ in an R2 research university compared to a regional university?

    H2: Academic factors will have the greatest influence on persistence and there will not be a significant difference between the research and regional universities.

3. What university retention strategies have influenced engineering school persistence as perceived by students? How do these differ in an R2 research university compared to a regional university?

H3: Mentor strategies will have the greatest influence on persistence and there will not be a significant difference between the research and regional universities.

4. Is there a significant difference in engineering persistence factors among genders and race/ethnicity groups?

H4: Social factors will be different for genders on engineering persistence factors.

H5: There will be no difference for race/ethnicity on engineering persistence factors.

This study intends to identify persistence factors in the colleges of engineering at a research and regional university and compare if there are differences between those types of universities. It will also look at gender and race/ethnicity to identify persistence factors.

Significance of Study

The data from this study can influence P-20 education by providing secondary and postsecondary institutions with the contributing factors that allow students to persist in engineering to graduation. In secondary schools, this data can help with implementing appropriate support in academics and career counseling so students are better prepared for majoring in engineering in college. Postsecondary institutions can use data from this study to provide appropriate retention programs so students feel supported and are more likely to persist to graduation. Knowing if there is a difference between an R2 research university compared to a regional university will provide postsecondary institutions with valuable data on the types of retention programs that could be successful for them compared to general programs that may not have as much influence on retention.

Definitions

Affluent school is characterized by a higher socioeconomic status of the student body with more resources and opportunities available for their students (Niu & Tienda, 2013).

Chilly climate is a cold and intimidating atmosphere in the engineering academic setting (Daempfle, 2002).

Classroom climate is the overall atmosphere, interactions, and relationships in a learning environment (Daempfle, 2002).

Co-op is longer-term work experience, typically paid, and offers academic credit (Lin, 2017).

Dual enrollment is where a student is enrolled in a college-level course while simultaneously earning credit toward their high school diploma for the same course (Conley, 2007).

Engineering identity is the personal, social, and professional aspects of being an engineer (Hughes et al., 2019).

First-generation student is an undergraduate student whose parents did not attend postsecondary education (Dowd & Coury, 2006).

Flexible mindset is a student’s belief in their potential for growth in abilities and intelligence (Sternberg, 2013).

Internship is work experience that may be short-term, may or may not be paid, and may offer academic credit (Lin, 2017).

Learning communities consist of a group of students who take the same classes, live in the same residential area, and have shared activities or events (Geisiner & Raj Raman, 2013).

Locus of control is the degree to which students believe they have control over their academic achievements and the factors that contribute to their decision to persist (Bean, 1988; Bean & Eaton, 2001).

P-20 is all levels of education, stakeholders involved, and life-long learning (Murray State University, 2023).

Persistence is the social and academic reasons a student chooses to continue in their academics at a university (Bean, 1988; Tinto, 1975).

Project Lead the Way is a PK-12 applied learning engineering curriculum designed to provide critical thinking and student experience in engineering (Cole, 2013).

Remedial class is a course that provides additional support to students who are not adequately prepared for college-level work in English or math (Adelman 2006; Therriault & Krivoshey, 2014).

Residential Status is the location where a student lives either on campus, at home, or off campus (Walsh & Kurpius, 2015).

Resiliency is the ability to achieve successful outcomes concerning challenging circumstances (Sternberg, 2013).

Self-regulation skills are an individual's ability to control their thoughts, behaviors, and emotions to achieve their goals (Sternberg, 2013).

Social Support is the assistance, care, and resources provided by an individual's family, friends, and peers that lead to the individual's well-being and success (Walsh & Kurpius, 2015).

Student departure is a student choosing to withdraw from a university (Bean, 1988; Tinto, 1975).

Self-efficacy is a student's belief in their capability to perform at a certain level (Smart, 2010).

Student engagement is the time and effort students devote to activities that are linked to desired outcomes for student success including academic, social, institutional, and cognitive (Hu, 2011).

Student integration is the social and academic integration of a student in the university setting (Tinto, 1975).

Summary

The increase in demand for engineers coupled with the decrease in engineers graduating and being retained at universities has caused a shortage in the field. Some research has identified persistence factors in colleges of engineering to help lay the groundwork for the implementation of retention programs. There have been mixed results on the success of colleges of engineering retention programs as retention rates have remained similar. With some students choosing regional universities over the R1 research universities there is a need to understand if persistence factors differences exist. This study aims to identify persistence factors and compare those factors for an R1 research university with an engineering program and a regional university with an engineering/physics and one engineering program. Chapter II of this study will outline the literature to help better understand the theoretical framework this study is built upon, general college persistence, engineering college persistence, and previous retention programs and their success.

Chapter II: Literature Review

Persistence/Retention in Colleges Institutions and Colleges of Engineering

Since the 1970s college persistence rates have diminished for students completing degrees in four to six years. Beginning in 1970, four-year graduation rates were 50% and six-year graduation rates were 75%. By the mid-1990s the rates had dropped to 30% and 60%, and in 2000 to 33% and 58%, respectively (Niu & Tienda, 2013). From that point general college persistence rates have remained fairly consistent at around 57% for students completing degrees within six years (Walsh & Kurpius, 2015). Interestingly, the majority of students who leave college are freshmen as data suggests around 57% of freshman students will not persist past their first year (Steward et al., 2015; Veenstra, 2009; Walsh & Kurpius, 2015).

Most of the research on persistence has focused on general college persistence with limited research on specific majors. While this is a growing area of research for college admission/retention programs it is limited in comparison to general persistence. Colleges of engineering have experienced a decrease in enrollment even with the need to increase students graduating with engineering degrees to meet the anticipated demand (Hughes et al., 2019). A decrease in enrollment with persistence rates around 40-60% has influenced the need for more engineers to meet industry demand (Cole, 2013; Desai & Stefanek, 2017; Geisinger & Raj Raman, 2013; Hall, et al., 2015; Hughes et al., 2019; Kuley et al., 2015; Ohland et al., 2008; Santiago, 2013; Shuman et al., 2000). Persistence rates are similar to general university persistence rates but first to second-year persistence is of growing concern since half of this attrition occurs in the first or second semester (Ohland et al., 2008; Shuman et al., 2000). Even though persistence rates to graduation are similar for engineering, matriculation from other majors into engineering is far less than any other major with over 90% of students that graduate having identified engineering as their major when they entered college (Ohland et al., 2008).

With the United States graduating less than 8% of new engineers each year globally and the need for engineers growing, it is imperative that research focuses on what factors contribute to persistence in engineering (Kuley et al., 2015; Lin, 2017). Retention is a priority in most colleges of engineering but, persistence factors to help with retention programs are complex (Kuley et al., 2015). Research on engineering persistence has identified stayers and leavers academically similar, pre-enrollment variables, institutional factors, personal factors, social factors, and other academic factors as reasons students stay or leave (Burtner, 2004; Desai & Stefanek, 2017; Hewitt & Seymour, 1994; Ohland et al., 2008; Santiago, 2013; Santiago & Hensel, 2012). Honken and Ralston (2013) found that freshman students leaving early had different characteristics and reasons compared to students who left after freshman year. This identifies the need for additional research on engineering persistence factors that could contribute to better retention programs for colleges of engineering.

Persistence Theories

As persistence declines the need for research and understanding to address the problem has increased with three main developmental theories evolving. These persistence models look at the college experience through academic and social factors that would contribute to students staying or leaving the college institution (Hu, 2010; Suhre et al., 2007). Tinto's (1975, 1993) theory of student departure with the development of the student integration model is a basis for many research models on persistence in higher education (Smart, 2010). Bean (1988, 2001) developed a model of student departure based on a critique of and research on Tinto's model. Astin (1999) developed the model of student involvement and developmental theory that identifies five areas that influence a student's persistence to degree completion. These three models are the basis for the vast majority of persistence research in higher education.

Tinto's Student Integration/Interactionalist Theory

A prominent theory that laid the groundwork for future research on college persistence is Tinto's (1975) theory of student departure and his development of the student integration model (Walsh & Kurpius, 2015). Tinto's (1975, 1993) model identifies an inability to integrate socially and academically as the reason students leave college due to their lack of commitment to the university. Prior research to Tinto described differences in outcomes but did not explain what contributed to those outcomes of student persistence (Smart, 2010). Tinto (1993) provided a longitudinal model with institutional-level, longitudinal/interactional, and policy-relevant characteristics.

According to Tinto (1975, 1993), only 15%-25% of student departures are a result of academic failure, so there has to be more explanation as to why students leave (Leppel, 2001). Students will enter college with diverse backgrounds in pre-college academics and family variables that influence academic and social integration and their commitment to the college (Elkins et al., 2000; Jackson et al., 1993; Tinto, 1993; Walsh & Kurpius, 2015). These factors, according to Tinto (1993), are important but what happens in college has more influence (Walsh & Kurpius, 2015). Integration in the college environment is another persistence factor in this model with on-campus living, separation from home, and faculty and other student interactions contributing to persistence (Veenstra et al., 2009; Walsh & Kurpius, 2015). The more experiences that shape a student's social and academic integration the higher the likelihood a student will persist to degree completion (Leppel, 2001; Tinto, 1993).

Tinto’s (1975, 1993) model describes pre-college factors such as family background, skills, abilities, and high school academics as the beginning factors contributing to persistence. If a student can transition or separate from their family environment to college and integrate themselves academically and socially they will be able to have a higher chance of persisting (Tinto, 1975; Tinto 1993; Veenstra et al., 2009). With these factors and having a goal of completing college and committing to the college, a student will increase the probability of persisting to graduation (Tinto, 1975; Cabrera et al., 1992). The student’s goals may change due to interest level, which could cause them to change majors but persist to college completion (Veenstra et al., 2009). Tinto’s work on student departure provided a foundation for future longitudinal research on college persistence based on the social and academic integration of students (Smart, 2010).

Model of Student Departure

Bean (1988, 2001) developed a model of student departure from research and critiqued Tinto’s (1975, 1993) student integration theory. Although Tinto (1975) described academic and social integration as reasons for persistence, Bean and Eaton (2001) argue that it failed to explain the mechanism through student integration. The student departure model identifies self-efficacy, self-control, and coping skills with learning and motivation as how students are academically and socially integrated (Smart, 2010).

Psychological, environmental, and academic interaction is another influence on student persistence in Bean’s model (Leppel, 2001). Psychologically, a student’s behavior will help shape if they persist based on their beliefs or locus of control (Cabrera et al., 1992; Smart, 2010). An internal locus of control explains a student’s reasoning that they are responsible for current and past successes/failures (Smart, 2010). A student with an external locus of control will believe success and failure are by chance or luck (Smart, 2010). Bean and Eaton (2001) identified the internal locus of control as a psychological factor for students' persistence due to the motivation to study and socialize resulting in academic and social integration. Environmental factors are partly the responsibility of the institution according to Bean and Eaton (2001) and they help increase a student's self-efficacy for improved academic and social integration (Smart, 2010). The interaction of psychological, environmental, and academic interaction through self-efficacy, self-control, and coping skills with learning and motivation is how Bean (1988, 2001) describes how students can be academically and socially integrated to increase persistence.

Student Involvement/Development Theory

Astin's (1999) research was based on a UCLA longitudinal study of college persistence that focused on a behavioral model. The conclusion from the research was that student involvement is the primary reason for persistence (Veenstra et al., 2009). Involvement is considered the physical and psychological energy a student contributes to their college experience (Astin, 1999). If a student spends a lot of energy studying, being involved on campus, and socially connected to faculty and other students they are considered a highly involved student and have a higher likelihood of persistence (Astin, 1999). There are five areas that Astin (1999) identified in their involvement theory, 1) physical and psychological energy investment, 2) students' manifest involvement on a continuum, 3) it is both quantitative and qualitative, 4) student learning is proportional to student involvement, and 5) effective educational policies and practices should increase student involvement. The more involved the student is both in and outside of class, the more they learn and gain from college (Astin, 1999; Hu 2010).

General College Persistence

The three models discussed above have provided higher education researchers with a foundation to build future research in college persistence. As college persistence continues to be studied and admission/retention initiatives implemented based on the research, retention continues to remain around 57% for higher education institutes. This suggests the complexity of persistence factors including the blending of personal, academic, and background characteristics (Therriault & Krivoshey, 2014). There is a wide range of influences that will cause a student to persist and one factor that causes a student to persist may cause another student to leave (Therriault & Krivoshey, 2014). After a careful review of the available literature, general college persistence can be divided into pre-college, college, social, and personal factors.

Pre-college Factors

Background and preparation for college have been shown to influence a student's ability to be successful and persist to graduation. A student's high school academic preparation (measured by grade point average (GPA), grades, SAT and ACT scores, AP scores, end-of-course exams, dual enrollment, and intensity of high school curriculum including affluent vs. poor high schools) will influence persistence in college. Students with an average GPA of a C or lower are less likely to persist compared to a student who maintains above a C average (Reason, 2009; Terriault & Krivoshey, 2014). Reason (2009) found that students with an A-average are seven times as likely compared to a C-average student to complete college in four years. High school GPA influences academic achievement and positively influences cumulative college GPA which contributes to students remaining in school (Walsh & Kurpius, 2015). Veenstra (2009) found that high school GPA, class rank, SAT total, or ACT composite contribute to persistence because students come in less prepared if they are lower, and this causes students to struggle with freshman-level courses. Some findings suggest that students with high school success have a belief they will be successful in college contributing to persistence (Walsh & Kurpius, 2015).

Standardized testing such as SAT, ACT, and end-of-course exams have been identified as factors in college persistence. Students with low scores on college entrance exams, SAT and/or ACT, are less likely to persist in college compared to students who receive high scores (Ryan, 2004; Therriault & Krivoshey, 2014). Ryan (2004) found students who have high SAT scores were six times as likely to graduate college in four years compared to students with low scores. End-of-course exams are also a contributing factor as students who score below proficiency could be at risk of not persisting in college (Conley, 2007; Therriault & Krivoshey, 2014).

Students enrolled in dual credit and scoring well on AP exams are more likely to persist in college (Conley, 2007; Hughes et al., 2019; Therriault & Krivoshey, 2014). If a student is enrolled in dual-credit courses specifically focused on career-type courses located on a college campus they are more likely to persist (Hughes et al., 2019; Therriault & Krivoshey, 2014). It was suggested that a reason for this is participating in a dual-credit program helps students understand the skills required to be successful in college (Hughes et al., 2019; Therriault & Krivoshey, 2014). Not all students who take AP courses have seen success in persistence. Students who score above a three have a higher likelihood of persisting, suggesting that a solid content foundation is critical to college success (Conley, 2007; Therriault & Krivoshey, 2014).

High school curriculum and the type of high school a student attends will influence persistence in college. Adelman (2006) found that 95% of students will complete a bachelor's degree if their high school transcript meets specific characteristics. Those characteristics included an intense high school curriculum of at least 3.75 units of English and math (calculus, precalculus, or trigonometry at minimum), 2.5 units of science, 2.0 units of foreign language, history, and social studies, 1.0 units of computer science, one or more AP courses, and no remedial courses in English or math (Adelman 2006; Therriault & Krivoshey, 2014). Students who attend better high schools or are from more affluent high schools persist at higher rates (Niu & Tienda, 2013). Intensity of curriculum, class offerings, and highly qualified teachers were identified as potential reasons for this difference (Niu & Tienda, 2013).

College Factors

After students are enrolled and attending college there are academic factors that contribute to their success and persistence. As mentioned, Tinto (1993) suggests that only 15%-25% of students who leave come from academic failure, but more recent research identifies academic performance as a major contributing factor to persisting in college. Many factors fall under academic performance that research explores as possibilities in persistence factors. These include first semester GPA, participation in remedial classes, completing a two-year degree with transferring to a four-year institution, and additional institution factors.

Freshman year is one of the most critical times as that is when most students will decide to leave and research suggests first semester GPA and cumulative GPA as factors for students to not persist. Academic performance has been found in multiple studies as the most significant factor contributing to a freshman continuing to sophomore year (Braunstein et al., 2001; Reason, 2009; Steward et al., 2015). Students maintaining a college GPA of C-average or lower are less likely to persist and as the GPA decreases so does the likelihood of completing a degree (Therriault & Krivoshey, 2014). If a student is in the top 40% of GPAs in college they are more likely to complete a college degree (Adelman, 1999).

Some students will enter college unprepared for academic courses and need to take remedial, non-credit-bearing courses. While this connects back to pre-college factors, taking remedial courses in college seems to be an indicator for first-year students dropping out (Adelman, 1999; Conley, 2007). There is some conflicting research on remedial courses and persistence. Most studies have indicated that taking five or more remedial courses significantly reduces a student earning an associate's or bachelor's degree (Adelman, 1999; Conley, 2007; Stewart et al., 2015). While Adelman (2006) found no significant relationship between remedial courses taken and graduation but did show an influence on time to graduation. In this same study, credits earned influence student's persistence to graduation (Adelman, 2006; Therriault & Krivoshey, 2014). If a student earned less than 20 credits by the end of freshman year they were one-third as likely to graduate (Adelman, 2006).

Along with academic factors, there are institutional factors that contribute to students not persisting. The rigor of the institution's curriculum is an institutional factor identified by Niu and Tienda (2013) as a reason for students to leave college. Other institutional factors such as the student-institution academic match, the size of the institution, distance from home, and the cost have shown significant correlations to student persistence (Cabrera et al., 2000; Niu & Tienda, 2013). Quality of classroom instruction where students feel instructors are not clear or effective, contributes to a decreased likelihood of persistence to graduation (Therriault & Krivoshey, 2014).

Social Factors

From the three models, a consistent finding is the social engagement or integration that contributes to persistence. The social experience a student has is the degree to which they interact with peers and school faculty (Therriault & Krivoshey, 2014). Identifying with the institution leads to persistence and a greater involvement with peer interaction increases this likelihood (Therriault & Krivoshey, 2014; Titus, 2004). The more a student is engaged with faculty on formal and informal contacts are more likely to persist (Therriault & Krivoshey, 2014; Tinto, 1975). In a study by Hu (2010), a non-linear relationship was found between student engagement and persistence. A high level of social engagement increased the probability of persisting, but a higher level of academic engagement was negatively related (Hu, 2010). The increase in academic engagement, if not accompanied by high social engagement, decreased the likelihood of a student persisting (Hu, 2010). High-level engagement without high social engagement persistence rate was 62.8% which was just slightly better than low-level engagement in academic and social activities at 59.3% (Hu, 2010).

Disengagement from the university environment such as not participating in extracurricular activities or social activities with other students decreases persistence (Therriault & Krivoshey, 2014; Titus, 2004). This disengagement usually occurs over time as the student disconnects from the environment and then becomes more psychologically distant (Sternberg, 2013). Students who are part-time compared to full-time have a higher risk of developing this disengagement. If a student is part-time they are less likely to persist and a student who switches to part-time from full-time reduces their probability of degree completion by 30% (Adelman, 2006; Therriault & Krivoshey, 2014).

Residential status can also influence university engagement. Students who live on campus increase their possibility of persistence by having increased access to academic and social engagement (Walsh & Kurpius, 2015). First-year persistence is important as mentioned, and students who live on campus are more likely to make it through their first year (Walsh & Kurpius, 2015). Along with the social aspect of living on campus Walsh and Kurpius (2015) reported higher GPAs for those living on campus compared to those off campus.

Personal Factors

College and social factors have been easier to measure in research to help identify specific factors that contribute to persistence. Personal factors are more complex as each individual may have specific reasons to not persist that are sometimes out of their control. Life experiences can directly impact persistence by altering the ability of the student to focus on academic or social integration (Therriault & Krivoshey, 2014). Tinto (1975) noted being a single parent, a first-generation college student, or coming from a low-income family as hurdles to persistence. With the complexity of personal factors, recent research has focused more attention on these factors to help identify areas for universities to support students for success.

Self-efficacy and resilience have developed recently as research areas to help understand these personal factors of persistence. If a student comes to college unprepared or the feeling of unprepared, they may feel uncertain about their ability to succeed (Sternberg, 2013). This initial low self-efficacy can drive a student to leave college early. Other students may come feeling prepared and the thought they will succeed only to perform badly on beginning test(s) or class(es) and their self-efficacy begins to fall (Sternberg, 2013). If students do not have the resiliency to overcome these obstacles they risk not persisting (Sternberg, 2013). Some studies have suggested that the most important predictor of performance and persistence is self-efficacy and resilience (Robbins et al., 2004; Walsh & Kurpius, 2015). Robbins et al. (2004) found self-efficacy to be the strongest predictor of retention in their analysis of self-efficacy, academic goals, and academic-related skills.

When students enter college, they have specific goals for themselves and the ones that have high expectations and strong goals have a higher likelihood of persisting to their sophomore year (Therriault & Krivoshey, 2014). Having a college major that interests the students compared to taking only the required courses during freshman year increases persistence (Sternberg, 2013). It was found that students who take at least one course solely based on interests during freshman year was a predictor of persistence (Sternberg, 2013).

In one study by Sternberg (2013), they found that students who have self-regulation skills and a flexible mindset increase the likelihood of persisting to graduation while students with psychological issues face more difficult challenges and have higher rates of leaving. Students who adjust to being on their own similar to Tinto's (1975) stage of separation will have the self-regulation skills to be successful. Extrinsically motivated students with limited self-regulation skills decrease the probability of persistence (Sternberg, 2013). Similar to self-efficacy and resiliency, having a flexible mindset when they make mistakes contributes to persistence (Sternberg, 2013). Psychological issues such as learning disabilities, attention/hyperactivity disorders, and autism-spectrum disorders were found to have higher rates of students not persisting (Sternberg, 2013).

Parent education level and income contribute to persistence in research as multiple studies have found correlations. Niu and Tienda (2013) found family background as a key determinant of college persistence, with it being largely responsible for academic performance. Stewart et al. (2015) identified parental income as the third most influential factor in predicting persistence, while Braunstein et al. (2001) found families that have greater income correlate with students who persist. In contrast, Elkins et al. (2000) found no correlation between parent education level and persistence but did find a correlation between persistence and parent income.

Social support, which is similar to Tinto's stage of separation, causes some students to not have the support they need to graduate. Walsh and Kurpius (2015) identified parents' valuing of education with positive persistence due to parental support. They did find that parental valuing of education lost its predictive power when other variables were added to the equation, but it was worth noting that parental valuing influenced students' valuing and their self-belief to persist (Walsh & Kurpius, 2015). The community environment is an additional social support that can influence college persistence with support increasing a student's chance of success (Reason, 2009; Therriault & Krivoshey, 2014). This community environment includes parents, friends, classmates, siblings, other relatives, high school teachers, and campus peers (Elkins et al., 2000).

First-generation students face the tough challenge of attending and completing college. When a student is the first in their family to attend college, they have a higher risk of leaving early (Dowd & Coury, 2006). Being a first-generation college student connects with parents and community support, as many of these students do not receive the support needed to be successful. Hsiao's (1992) research concluded the inadequate support of parents, siblings, and friends with no college experience decreases the possibility of the student graduating. First-generation students also experience a lack of informal knowledge of being a college student which Sternberg (2013) found to negatively impact the community environment support needed.

Degree program satisfaction was researched by Suhre et al. (2007) who concluded that students who are dissatisfied risk leaving early. They found a strong relationship between satisfaction and persistence and if a student had perceived high levels of satisfaction with their degree program during freshman year they were more likely to persist (Suhre et al., 2007). They hypothesized from their findings that students who are dissatisfied may lose interest and motivation to study which affects their academic performance (Suhre et al, 2007).

Personal finances also influence whether a student will persist to graduation. Part of finances is the knowledge of how to access financial assistance for those in need of financial support (Therriault & Krivoshey, 2014). There are inconsistencies in the relationship between persistence and financial assistance in research studies. Stewart et al. (2015) found a significant relationship between financial aid on college GPA and student persistence. Sternberg (2013) identified financial concerns as a major risk factor for persistence with students dropping out because they cannot make college work financially. In two other students financial aid was found to have no significant impact on persistence and degree attainment (Braunstein et al., 2001; Dowd & Coury, 2006). Related to finances, students who work more than 20 hours per week decrease the likelihood of graduating (Therriault & Krivoshey, 2014).

Gender and race have also been shown to be a factor in college persistence. In a 2015 study, Black students were found to have lower persistence rates than White students (Stewart et al., 2015). Gender has conflicting research results with at least one study concluding women graduate at higher rates than males (Reason, 2009), while another study showed no significant difference between genders (Stewart et al., 2015).

Engineering School Persistence

In recent years researchers have branched off into field of study or major persistence to see if there are identifying factors specific for those majors compared to general persistence. While most of the research identifies overlaps of factors, there are specific factors that have been identified. Engineering schools have had difficulty with retention rates and graduating qualified engineers over the past few years. With these concerns research in engineering persistence is of great value. Engineering persistence is similar to general persistence with pre-college, college, social, and personal factors being the main factors but within those main categories, there are differences specific to engineering.

Engineering Pre-College Factors

A study by Veenstra et al. (2009) considered specific pre-college factors that are prevalent in engineering education empirical studies on college persistence in comparison to general college persistence. The major differences identified for engineering college persistence pre-college factors were quantitative skills and confidence in quantitative skills (Veenstra et al., 2009). Additional studies have found study habits, science skills, high school mentor and their knowledge of engineering, and students participating in the pre-engineering curriculum as factors specific to engineering school.

Similar to general college persistence, students must have proper high school academic preparation, including proper study habits to persist to graduation (Suresh, 2007). Engineering curriculum is difficult and students need proper high school preparation with the lack of preparation being a factor in students' leaving engineering school (Geisinger & Raj Raman, 2013). Garcia-Ros et al. (2018) found a direct effect on pre-college preparation and academic results in engineering, specifically during their first year. Study habits developed in high school also connect with persistence in engineering school (Honken & Ralston, 2013; Veenstra, 2009).

High school preparation can be measured by high school GPA, high school rank, total SAT, and ACT composite scores concerning persistence (Veenstra, 2009). Multiple studies have identified high school GPA as a significant predictor of retention in engineering school (French et al., 2005; Geisiner & Raj Raman, 2013; Hall et al., 2015; Honken & Ralston, 2013; Moses et al., 2011; Veenstra, 2009). In one study specific to Mercer University College of Engineering, the researcher found high school grades to be the greatest predictor of student retention and success (Burtner, 2004). While general persistence relies on overall SAT and composite ACT scores, engineering school research has looked more specifically at SAT and ACT math scores as well as overall. ACT math and SAT math scores have been identified as significant predictors of engineering school retention in multiple studies (Burtner, 2004; French et al., 2005; Geisinger & Raj Raman, 2013; Hall et al., 2015; Honken & Ralston, 2013; Moses et al., 2011; Veenstra et al., 2008). In one engineering school study, the engineering statics course which is their perceived gatekeeper for engineering had the largest correlation between SAT math scores and success in the statics course (Hall et al., 2015).

Math skills have also been measured through high school calculus grades and perceived math confidence. Students with less math preparation have a higher likelihood of leaving engineering or the students require additional support to persist compared to peers (Kuley et al., 2015). This predictor of persistence is unique to engineering retention. Entering engineering school below calculus level has shown a probability of success at 30% compared to students entering at calculus or higher with a probability of 50%-75% success to graduation (Krause et al., 2015). Multiple other studies have shown math aptitude, specifically calculus, to be a strong predictor of engineering retention (Geisinger & Raj Raman, 2013; Hall et al., 2015; Honken & Ralston, 2013; Tyson, 2011; Veenstra, 2009). Honken and Ralston (2013) concluded students had transferred out of engineering due to a lack of math preparation. Along with math skills, math confidence from their pre-college math preparation has been shown to be a significant indicator of success. Veenstra (2009) measured students' math confidence through self-rating and concluded the students with higher perceived math confidence performed better and had lower dropout rates.

Science skills from high school preparation as measured by ACT science and science, physics, and chemistry grades are a significant predictor of retention (Geisinger & Raj Raman, 2013). Honken and Ralston (2013) also concluded in their study that students transferred out of engineering due to a lack of science preparation. Science preparation is specifically important for success in college physics and chemistry (Geisinger & Raj Raman, 2013; Veenstra, 2009).

High school mentors and teachers who have engineering knowledge have been shown in research to impact student retention and persistence (Eris et al., 2010; Hirsch et al., 2006). Students who persist have been identified as more motivated by their high school mentor compared to students who leave (Eris et al., 2010). In their study, Eris et al. (2010) suggested mentors help increase student motivation to study engineering by helping develop math and science confidence. In a study by Hirsch et al. (2006) the researchers followed teachers' integration of engineering principles into their classrooms and concluded the students in their classes developed positive attitudes and knowledge about engineering which influenced student's retention in engineering.

Many schools are now starting to implement pre-engineering curricula in high schools. There is conflicting evidence from research on pre-engineering in high school and engineering school retention success. Cole (2013) researched Project Lead the Way (PLTW) curriculum at a regional career technology center to see the impact it had on student's persistence and success at Oklahoma State University. Results showed that students persisted at a similar rate as general students and were comparable to the average retention rate of national estimates (Cole, 2013). In the findings, Cole (2013) suggested there may be a positive impact on engineering enrollment. In a similar study, McCharen (2010) found higher rates of persistence for students who had taken pre-engineering in high school and Miller (2020) concluded that students who had taken pre-engineering were two times as likely to enroll in engineering. Utley (2009) concluded that PLTW participation did not have an impact on engineering degree completion but did impact retention from freshman to sophomore year. Tran (2010) found PLTW had a positive impact on high school math performance which helps increase math preparedness.

Engineering College Academic Factors

Institutional and classroom climate have been identified by students as reasons they decide to leave engineering. In the literature, the type of classroom climate seen in many engineering schools is called the chilly climate hypothesis (Daempfle, 2002). Terms such as cold, elitism, aloofness, and rejection have been used by students to describe this climate (Daempfle, 2002; Seymour & Hewitt, 1994). Students also express faculty concern and describe their personalities as unapproachable, cold, unavailable, and intimidating (Daempfle, 2002; Seymour & Hewitt, 1994). These attributes of a chilly climate have developed an unwelcoming atmosphere and resulted in some students' decision to leave because of the weed-out culture developed (Meyer & Marx, 2014). In a study by Geisinger and Raj Raman (2013) over half of the participants identified the classroom and academic climate as their reason for leaving engineering. With this weed-out culture mentality, students feel faculty do not like to teach and do not value teaching above their research (Daempfle, 2002; Seymour & Hewitt, 1994; Suresh, 2007). Poor teaching, interactions with faculty, and lack of encouragement and attention from faculty have been reported as reasons students leave (Geisinger & Raj Raman, 2013; Marra et al., 2012; Meyer & Marx, 2014; Suresh, 2007). Traditional teaching strategies are individualistic and competitive compared to cooperative influence persistence (Geisinger & Raj Raman, 2013). Students also identified the competitive environment in the weed-out culture as hostile and this type of teaching style was an important predictor of student success and retention (Geisinger & Raj Raman, 2013). An increase in the frequency and quality of positive faculty interactions increases the likelihood of engineering persistence (Santiago & Hensel, 2012). Students who do ultimately leave these climates reported negative feelings toward the school with feelings that the school of engineering did not want them to succeed (Kuley et al., 2015).

Another aspect of institutional climate and faculty interaction is the reported disappointment with academic advising. Students have reported a cold climate with advisors and felt discouraged from continuing to pursue an engineering degree (Meyer & Marx, 2014). Similar to the classroom climate, the faculty seemed too busy or did not care to provide proper advising (Godfrey et al., 2010; Meyer & Marx, 2014). Marra et al. (2012) found poor advising as a significant contributor to persistence.

College GPA is a factor in retention in engineering school. Low grades help drive students to other majors that do not have as rigorous a curriculum (Geisinger & Raj Raman, 2013). Hall et al. (2015) concluded that college GPA is the only factor to be a significant predictor of retention and a student's persistence in engineering. Additional studies have supported the fact that cumulative GPA is the main contributor to student's persistence (French et al., 2005; Jackson et al., 1993; Veenstra et al., 2008). In a study by Veenstra et al. (2008), they determined that students had switched out of engineering by their third semester if they had a low GPA. Another study by Shuman et al. (2000) found that only 25% of freshmen and 33% of sophomores to seniors had identified academics as the primary reason they left.

One of the main academic contributions to persistence is that engineering is a difficult curriculum (Marra et al., 2012). With the first year being the most critical in persistence, many students complained of theoretical and stagnant curriculum early on, which led to negative perceptions about the engineering career (Kuley et al., 2015). During freshman year, an inadequate understanding of freshman engineering courses caused some students to leave (Meyer & Marx, 2014). There are many difficult courses students take and some identified difficulty with course material as a reason for discouragement and not persisting (Geisinger & Raj Raman, 2013). Of these difficult classes, chemistry and calculus have been shown to be the biggest contributing factors to not persist (Bernold et al., 2007; Krause et al., 2015; Mau, 2003; Santiago, 2013). The grade a student receives in their first math course, which is typically calculus, will determine if the student will successfully persist to graduation in engineering (Krause et al., 2015). A contributing factor for this reason is most universities have a grading policy for calculus. If a student obtains a grade below a C in calculus or takes a course below calculus, this will prevent that student from continuing in engineering coursework to their second semester (Krause et al., 2015). In a study by Santiago (2013) they found not only calculus to be a contributing factor to success but also entry-level chemistry. Those two courses were the significant factors in the reason students switched majors (Santiago, 2013).

Engineering Social Factors

Students have reported the difficulty of engineering curriculum and trying to balance social life with school (Santiago, 2013). Time management has been identified as a reason students leave engineering and try to balance social life away from home for the first time (Meyer & Marx, 2014; Santiago, 2013). Some of these social factors can be attributed to peer influence in both positive and negative ways. The demanding courses and students not being socially engaged contribute to them not persisting (Veenstra, 2009). Positive social engagement has shown an increase in students’ persistence with students participating in internships and studying with peers being a significant predictor (Hughes et al., 2019). Peer mentorship also has been shown to have a positive impact on persistence with Kuley et al. (2015) suggesting students have someone to look up to and are more likely to feel they fit in and belong.

Similar to general college persistence, studies on social integration into the institution for engineering students have been shown to increase persistence (Meyer & Marx, 2014). An imbalance of social and academic integration puts engineering students at risk of leaving (Meyer & Marx, 2014). Both Garcia et al. (2018) and French et al. (2005) identified institutional integration as a noncognitive factor that contributes to engineering student retention.

Engineering Personal Factors

Just like general college persistence, engineering programs are looking at the complex personal factors that contribute to student retention. Some of the factors are the same but on a different scale due to the difficulty of an engineering curriculum. Students have reported in literature self-efficacy, sense of belonging or engineering identity, loss of interest or career goals, lack of study and survival skills, lack of confidence, stress, personality, motivation, parents background, support and pressure, and finances as reasons for not persisting in engineering school.

Self-efficacy typically decreases in students who experience discouragement from low grades or failure of a prerequisite course in engineering (Geisinger & Raj Raman, 2013; Meyer & Marx, 2014). If faculty are accessible, students report higher self-efficacy and GPAs (Geisinger & Raj Raman, 2013). Female students in engineering who have lower self-efficacy have higher rates of dropping out or switching majors (Kuley et al., 2015). In their study, Kuley et al. (2015) concluded faculty relationships, institutional climate, and teaching methodology as contributing factors to self-efficacy. Students who have prior experience with engineering through pre-engineering or engineering hobbies have higher levels of self-efficacy and greater persistence (Fantz et al., 2011). Mau (2003) found that academic proficiency and math self-efficacy are the most predictive variables in persistence. Confidence in math and science skills contributes to not persisting even with students who are in good academic standing (Eris et al., 2010). Burtner (2005) found at Mercer University that freshman end-of-year attitudes predicted persistence with confidence in math and science ability being the significant predictors. Interestingly, Burtner (2004) found in another study that problem-solving skills confidence was the same for students who persisted and those who did not.

An engineering-specific factor different than general college persistence is engineering identity. If students do not identify with engineering they lack a sense of belonging in the major and have a higher risk of not persisting (Geisinger & Raj Raman, 2013). The lack of a sense of belonging and engineering identity is a primary factor that underlines students' persistence even if they are academically successful (Hughes et al., 2019). Developing a sense of belonging helps students connect with peers in engineering and helps them participate in other engineering opportunities, in turn increasing their engineering identity further (Hughes et al., 2019). Marra et al. (2012) concluded that the lack of belonging or engineering identity could be related to their self-efficacy leading them to leave engineering. If students develop this lower self-efficacy due to not identifying with engineering they are less likely to change majors to another technical field major (Marra et al., 2012). A Meyer and Marx (2014) study identified all participants as mentioning lack of belonging as the reason they left engineering. In the study, student's performance dropped, self-efficacy dropped, and they were not able to regain a sense of belonging in the engineering program (Meyer & Marx, 2014). Engineering identity is something that builds throughout college when students have a sense of belonging which helps with persistence (Hughes et al., 2019). If students lack a sense of belonging with peers, they will find it difficult to fit in and do not feel they can be an engineer (Kuley et al., 2015). Hughes et al.

(2019) suggest that engineering identity may be the most important contributor to engineering persistence because it is central to learning, which is a precursor to success.

Confidence in study habits at the end of freshman year can contribute to students deciding to change majors or leave (Burtner, 2004). Study habits, work habits, coping strategies, and handling independence are also reported as contributing factors to student persistence (Santiago, 2013; Suresh, 2007). Being able to handle independence is a challenge some students face and cannot overcome so they leave engineering (Santiago, 2013).

Some students lose interest in engineering or change career goals which influences their decision to persist in engineering. These students leave because they discover a passion for other fields of study (Geisinger & Raj Raman, 2013; Santiago, 2013). When entering college some students are unsure of their interest in engineering and ultimately change majors because the major no longer matches their interest (Santiago & Hensel, 2012). In a study conducted by Shuman et al. (2000), they found that 72% of freshmen and 79% of sophomores through seniors who left engineering lost interest or developed interest in another field. They also found some students came to dislike engineering with 66% of freshman and 57% of sophomore-seniors identifying that as a factor for leaving (Shuman et al., 2000).

Stress causes some students to leave engineering as they do not see the major as worth the effort (Meyer & Marx, 2014). Some students also do not see an engineering degree as guaranteeing them a job so they change majors (Burtner, 2004). Santiago (2013) found that 49.4% of students identified the first semester as stressful. The stress associated with transitioning from high school to engineering and the difficulty of the first semester was too much for some students (Santiago & Hensel, 2012).

Students who display intrinsic motivation are more likely to identify role models they have that help them overcome obstacles to persist in engineering (Kuley et al., 2015). Motivation to succeed contributes to persistence and may be a reason some students persist even if they are struggling with the engineering curriculum (Suresh, 2007). Academic motivation is another reason a student may decide to persist even during difficult courses (French et al., 2005).

Parent background and parent support are contributing factors to engineering persistence according to the literature. Honken and Ralston (2013) concluded that students who have both parents with bachelor's degrees increased the likelihood of them remaining in engineering past their first year. In the study, 80% of students who left after their first semester and 50% who left the university altogether after one year did not have a parent who graduated from college (Honken & Ralston, 2013). While parents' level of education factors into persistence in engineering the specific major also impacts the persistence (Hughes et al., 2019; Veenstra, 2009). Engineering students who have a parent employed as an engineer influences that student's engineering identity and ultimately their persistence to graduation (Hughes et al., 2019). Veenstra (2009) found that parent support is a factor in persistence but, Eris et al. (2010) found that students that do not persist were motivated by parents to study engineering compared to students that persisted.

Research has also looked at personality types and variables that play a role in a student persisting in engineering. A study by Moses et al. (2011) found that a student's openness, locus of control, and neuroticism correlated to retention but only openness was a significant factor. The study defined openness as a student who seeks new experiences and is open to them (Moses et al., 2011). They concluded that the ones that left did not have academic issues but rather did not display an openness personality (Moses et al., 2011).

Finances are similar to general persistence but for engineering students research looks at the loss of scholarships as a determining factor. When students started to struggle and their GPA started to decrease they experienced financial difficulty due to loss of scholarships (Geisinger & Raj Raman, 2013). If financial difficulty arises or the needs are not met there is a greater likelihood of not persisting (Veenstra, 2009).

Engineering Gender/Race Factors

Many initiatives have been established to increase enrollment for women and minorities in engineering due to the lack of representation. Among industrialized societies engineering is the most sex-segregated non-military profession (Cech et al., 2011). From the initiatives that have been established to increase persistence in engineering, they have shown improvements for women and students of color (Ohland et al., 2008). Research that focuses on gender differences in engineering is important because only 15% of the field represents women with only 10% earning an engineering degree (Jackson et al., 1993). Current research has demonstrated gender differences in reasons for persistence in men and women (Jackson et al., 1993).

Women tend to leave engineering for other fields at higher rates than males even with the same or higher pre-college preparation (Geisinger & Raj Raman, 2013; Hughes et al., 2019). Kuley et al. (2015) found inconsistencies in the rate at which women leave engineering and suggested persistence depends on the institution. One study by Jackson et al. (1993) found women persisted at a rate of 67% compared to men at 73% although the women's perceived math and science abilities were lower than what the actual men's abilities represented. The reason for the lack of persistence has been shown to be different for females mainly due to overcoming the male-dominated profession (Geisinger & Raj Raman, 2013). Females tend to leave engineering at different points in their education compared to males (Kuley et al., 2015).

Early research identified factors such as student background, GPA, SAT scores, and self-perception of abilities as main contributors to female persistence (Jackson et al., 1993). More recent research has focused on engineering identity, treatment, self-efficacy, and institutional climate as factors for persistence in females (Geisinger & Raj Raman, 2013; Hughes et al., 2019; Kuley et al., 2015). Geisinger and Raj Raman (2013) reported female students leaving due to sexist treatment from male faculty and their male peers. With the field being male-dominated, females have reported lower self-efficacy which leads to a lack of sense of belonging or a lower level of engineering identity (Hughes et al., 2019; Kuley et al., 2015). Female students who enter engineering tend to be very committed and the ones with high self-efficacy can identify with the engineering profession by overcoming the barriers other females face (Kuley et al., 2015). Women who persist and graduate have been found to be more likely to have fathers who are engineers, be married to an engineer, or come from a well-educated family (Jackson et al., 1993). They also tend to place importance on career success compared to women who enter female-dominated fields (Jackson et al., 1993).

In an extensive study on female persistence in engineering, Cech et al. (2011) concluded multiple differences in female persistence compared to males. Family plans helped partially explain the reason behind females not entering engineering. Common expectations for women are to provide family care which has encouraged them to not pursue male-dominated fields (Cech et al., 2011). They did find that there was no evidence to suggest family plans impacted persistence once females were enrolled in engineering (Cech et al., 2011). Perceived low self-assessment of abilities in math and science lowers self-efficacy and is a contributing factor to female persistence (Cech et al., 2011). Professional role confidence or engineering identity contributed to females' lack of confidence and reduced the likelihood they would persist in engineering (Cech et al., 2011).

Similar to gender differences there are some conflicting results on race differences in engineering persistence. Geisinger and Raj Raman (2013) found that minorities leave engineering at higher rates than white males even with the same pre-college factors which are similar to gender. However, Therriault and Krivoshey (2014) found that African-American students in high-demand majors such as engineering are more likely to persist. Improving institutional climate has been shown to increase female persistence but it does not affect racial disparity in the same way (Kuley et al., 2015). Interestingly, minority students are at greater risk of leaving engineering later in the degree process (Kuley et al., 2015).

Engineering Retention Strategies

Part of the reason for engineering persistence research is to identify areas universities can focus their attention on to try and improve retention. Colleges of engineering are implementing retention strategies and programs to help students persist beyond their first year and provide support to graduation. Some admission departments are connecting with local high schools to improve pre-college factors while retention programs are focused on students as they get on campus. Most research and strategies focus on college factors as universities have limited control over pre-college factors.

Since academic difficulty has been identified as an influential factor in persistence, universities have established tutoring practices to help students with difficult coursework (Graffigna et al., 2013). Tutoring practices have been shown to be beneficial in helping students feel connected to the university and feel supported in their work to become an engineer

(Graffigna et al., 2013). Specific tutoring for calculus helps students overcome the difficult course and persist (Graffigna et al., 2013).

An aspect of persistence that is important is the social factors that contribute to a student feeling connected to the university. Social integration allows the students to connect with peers and the university to feel valued and persist (Tinto, 1975). Universities are utilizing mentorships to help with this social integration for students. Mentorships with industry partners, faculty, and upperclassmen engineering students have shown to be successful in retention (Kuley et al., 2015). Minority and female students seem to benefit the most from mentor programs due to their recorded lower self-efficacy in research (Kuley et al., 2015). Providing mentors gives these students support and increases their sense of belonging or engineering identity (Kuley et al., 2015). Wang et al. (2022) suggested mentorships for minority, female, and first-generation students to help increase student's self-efficacy and sense of belonging. Desai and Stefanek (2017) suggested every freshman engineering student should have a mentor to increase the likelihood of persistence and to provide support for difficult curriculum.

Many colleges of engineering recommend students participate in internships or co-ops to help develop skills and provide experience in the field of engineering while other programs embed these in their curriculum. Lin (2017) found that strong co-op/internship programs help recruit and retain students. Students who participate in internships or co-ops are a significant predictor with a higher likelihood of persisting to college graduation (Hughes et al., 2019). Hughes et al. (2019) suggested that internships and co-ops help students make real-world applications of the theoretical-based class work by increasing the student's sense of belonging or engineering identity. Additionally, embedding service learning opportunities into the curriculum has shown an increase in persistence for engineering students (Ohland et al., 2008).

Another aspect of social integration for universities is providing learning communities for students. Specific to engineering these learning communities have been shown to increase retention by increasing the climate of engineering school, improving student grades, improving self-efficacy, and improving self-confidence in math and science ability (Geisinger & Raj Raman, 2013). These learning communities have helped increase a sense of belonging or engineering identity through both academic and social support for all students including underrepresented groups (Desai & Stefanek, 2017).

Students who enter an engineering program not academically prepared from high school will have more difficulty and not persist at the same rates as their academically prepared peers. To help resolve this obstacle, some universities have established summer bridge programs specifically for math to help students become math-ready for calculus as freshmen. Students who enter below the calculus level have a 30% success rate of graduation whereas students at calculus or above have a 50% - 75% probability of graduating from engineering (Krause et al., 2015). One summer bridge study by Cancado et al. (2018) found that the program met its goal of improving math placement level but did not influence student's likelihood of success in engineering. The program did not include additional support through tutoring or other practices while the students were enrolled. They suggested ongoing support for students who enroll in the bridge program to help students throughout their experience (Cancado et al., 2018).

Colleges of engineering have seen the theoretical approach to teaching engineering as difficult for students because they do not experience the real-world application of engineering early on in their education which influences retention. In an effort to help improve retention, programs have looked to redesign the curriculum specifically for freshman-level courses. Redesigning curriculum has been shown to improve retention rates if it is supported by a respectful atmosphere, additional support for unprepared students, and more flexibility in students' schedules for them to take courses based on their interests (Kuley et al., 2015). These changes in engineering curriculum that combine with institutional climate have seen the most significant improvements in retention. Kuley et al. (2015) suggest the improvement in retention is due to curriculum and institutional climate factors influencing and interacting with all other factors. Part of the redesign is offering freshman-level engineering design courses that provide hands-on learning at the beginning of a student's educational journey (Bernold et al., 2017; Desai & Stefanek, 2017; Ohland et al., 2008). These hands-on freshman-level design courses have seen an increase in retention past freshman year which is a critical time for students' retention in engineering (Ohland et al., 2008). The purpose of the design courses is to help retain students by incorporating opportunities for students to solve practical engineering problems at the freshman level so they can apply the material from other courses to real-world problems (Desai & Stefanek, 2017). Without these courses to make real-world engineering applications students lose interest in engineering before they can fully understand what engineers do and decide to change majors. This is because the curriculum in the early years has been focused on theory compared to the hands-on application of the engineering curriculum (Kuley et al., 2015).

Engineering has the lowest matriculation rate of all majors with as low as 7% of students in their eighth semester of engineering that had matriculated from other majors (Ohland et al., 2008). Oklahoma University College of Engineering started offering a freshman exploring engineering course that is a requirement for all engineering majors similar to the freshman-level design courses mentioned above (Davis et al., 2012). This course is also available to non-engineering majors to increase retention for engineering majors and increase matriculation from other majors. In the study by Davis et al. (2012), they found that 57% of the students in the course had switched to engineering after taking the course.

Weed out and the chilly climate culture in engineering is something universities are trying to improve on in efforts to increase retention. Colleges of engineering are providing professional development for faculty toward student-centered learning practices (Krause et al., 2015). These strategies are to help faculty focus on improving teaching techniques and more effective teaching practices in early math courses (Desai & Stefanek, 2017; Krause et al., 2015). There have been some positive results from these practices to help reduce the weed-out and chilly climate culture (Desai & Stefanek, 2017; Krause et al., 2015).

Chapter III: Methodology

The purpose of this study was to research the persistence factors of university engineering student's post-pandemic and compare the results of an R2 research university and a regional university as well as compare genders and race/ethnicities. The R2 research university has an engineering program and the regional university has an engineering/physics program with the recent addition of one engineering program. Quantitative data was collected from students at an R2 research university and a regional university. The R2 research university is a large urban university and the regional university is a smaller rural university. All students with a declared major in engineering who are sophomores through seniors were invited to participate in the study. Quantitative data was collected through a survey related to persistence factors and sent to all students eligible to participate. The focus of the study was to see if persistence factors have changed since the pandemic compared to current research and to see if persistence factors are different for an R2 research university compared to a regional university as well as gender and race/ethnicity.

Research Design

A quantitative, nonexperimental, casual comparison, and descriptive research design was chosen for this study. Numerical data was collected from a survey to help explain a cause-and-effect relationship which is quantitative research (Ravid, 2020). Ravid (2020) states that descriptive research is used to study phenomena occurring naturally such as the factors that contribute to a student's persistence in engineering at different universities. A casual comparative study (also known as ex post facto) looks at comparing a cause-and-effect relationship like the factors that contribute to persistence (Ravid, 2020). The effect of the independent variable (persistence factors) on the dependent variable (student persistence) was studied. The purpose was to see what factors contribute to a student persisting and if there is a difference between an R2 research university compared to a regional university and if there are differences in gender and race/ethnicities.

Quantitative data was collected at two universities' engineering programs, an R2 research university which is a large urban school, and a regional university which is a small rural school. All students with a declared major in engineering who are sophomores through seniors were invited to participate in the study. Quantitative data was collected through a survey to identify perceived factors that have led to persistence in the engineering college. The survey used for this study was a modified version of the Student Persisting in Engineering Survey developed by Pennsylvania State University and the University of Missouri and published by Assessing Women and Men in Engineering (AWE, 2023). The initial data collected from the survey helped identify the factors that lead to persistence among students. Then data was analyzed for persistence factors' significance with the data being compared between the R2 research university and the regional university to determine significance. Persistence data was also analyzed for gender and race/ethnicities.

Research Questions and Hypotheses

The research questions were developed and modified from a study by Marra et al. (2012). The study looked at a single institution and the perceived factors of transferring out of engineering at that university. Predictor variables of high school preparation and future behaviors of chosen majors were studied to help determine the influence on why students leave engineering. Marra et al. (2012) focused on factors that influence the decision of a student to transfer out of engineering whereas this study focused on the factors that contribute to a student persisting. This study also includes retention strategies the university utilizes to retain students that have helped students persist which is not in the Marra et al. (2012) study. One final analysis included gender and race/ethnicity to determine if there are persistence factor differences.

1. What pre-college factors (academic, social, and personal) influence engineering school persistence as perceived by students? How do these differ in an R2 research university compared to a regional university?

    H1: Academic preparation will be the greatest influence on persistence and there will not be a significant difference between the research and regional universities.

2. What college factors (academic, social, and personal) influence engineering school persistence as perceived by students? How do these differ in an R2 research university compared to a regional university?

    H2: Academic factors will have the greatest influence on persistence and there will not be a significant difference between the research and regional universities.

3. What university retention strategies have influenced engineering school persistence as perceived by students? How do these differ in an R2 research university compared to a regional university?

    H3: Mentor strategies will have the greatest influence on persistence and there will not be a significant difference between the research and regional universities.

4. Is there a significant difference in engineering persistence factors among genders and race/ethnicity groups?

    H4: Social factors will be different for genders on engineering persistence factors.

    H5: There will be no difference for race/ethnicity on engineering persistence factors.

Setting and Sample

The research sample came from an R2 research university in a large urban city and a regional university in a small rural community. The researcher obtained IRB approval (Appendix A) from the regional university and that approval was emailed to the R2 research university. Due to the R2 research university only being used to recruit participation from the survey the Human Subjects Protection Program Office of the university approved the survey being sent to students through email (Appendix B). At the regional university, the director of the school of engineering was contacted to email the survey to students. The email with the survey and letter of consent was sent to 196 students (Appendix C). At the R2 research university, the associate dean of undergraduate affairs and director of undergraduate engineering studies was contacted to email the survey to students. The email with the survey and letter of consent was sent to 1,723 students (Appendix C). At the R2 research university engineering majors included the following: bioengineering, chemical engineering, civil engineering, computer engineering, computer science, cybersecurity, data science, electrical engineering, engineering fundamentals, engineering management, environmental engineering, healthcare systems engineering, industrial engineering, materials and energy science, mechanical engineering, structural engineering, and transportation engineering. At the regional university, engineering majors included the following: civil and sustainability engineering, aerospace engineering, electrical engineering, mechanical engineering, electromechanical engineering technology, manufacturing engineering, design engineering technology, and cybersecurity and network management.

Student emails were not allowed to be collected by the researcher so the above-mentioned directors of engineering at each university emailed the survey to sophomores through seniors currently majoring in engineering at the two universities. The subgroups of gender and race/ethnicity were collected in the survey. The researcher's goal for sampling included a minimum of 15 students from each school for a total of 30 students, which is the minimal sampling correlation for quantitative research (Ravid, 2020). The sampling size was dependent on the number of students that completed the quantitative persisting in engineering survey. All students were contacted through their school email accounts and asked to voluntarily participate in the study of persistence factors in engineering. A week after the initial email the researcher asked for a reminder email to be sent to increase participation. The regional university had 27 students participate and the R2 research university had 25 students participate for a total of 52 responses to the survey.

Risk

The risk associated with a quantitative, descriptive, and ex post facto study is the lack of control over the independent variables, potential bias, and limited generalizability. A lack of control over the independent variables is due to them already occurring which can limit the ability to establish relationships (Ravid, 2020). The researcher has experience with pre-college factors that influence persistence in college engineering students which could lead to potential bias. Generalization is possible from this study but since data will be collected from two different universities that do not have all characteristics similar to other R2 research and regional universities those generalizations can be limited (Ravid, 2020). With those risks in mind, the principal investigator is aware of the lack of control over independent variables, potential bias, and limited generalizability.

There is also a risk associated during data collection from the quantitative survey with the loss of confidentiality of participants. However, all identifying personal information collected by the principal investigator was securely stored on a personal laptop and external hard drive with both being protected by a passcode. Personal information and data collected for this study were not used for any other studies and are only shared through research data collection, analysis, and results.

Anonymity (volunteer participation, confidentiality)

Any engineering student who is a sophomore through senior from the two universities voluntarily chose to participate in the persistence factors survey. No students received compensation in any form either through monetary or academics. Students had the choice to participate in the survey and were made aware of receiving no compensation and all data remaining confidential.

All information that could be personally identifiable was inaccessible to everyone except the principal researcher and remained confidential throughout the study. No personal data was collected outside of gender and race/ethnicity and coded so that it could not identify a participant. All data was stored by the principal investigator and was not shared with anyone. Participant coding is represented in the table below.

Table 1

Coding for Persistence in Engineering Participants

Factor	Coding
School	1 = R2 Research University 2 = Regional University
Race/Ethnicity	1 = American Indian or Alaska Native 2 = Asian 3 = Black or African American 4 = Native Hawaiian or Pacific Islander 5 = White 6 = Hispanic or Latino 7 = Multiple Races/Ethnicities 8 = Prefer not to answer
Gender	1 = Male 2 = Female 3 = Prefer not to answer
School Year	1 = Sophomore 2 = Junior 3 = Senior
Engineering Major	1 = Aerospace engineering 2 = Bioengineering 3 = Chemical engineering 4 = Civil engineering 5 = Computer engineering 6 = Computer science 7 = Cybersecurity 8 = Data science 9 = Design engineering technology 10 = Electrical engineering 11 = Electromechanical engineering 12 = Engineering fundamentals 13 = Engineering management 14 = Environmental engineering 15 = Healthcare systems engineering 16 = Industrial engineering 17 = Manufacturing engineering 18 = Materials and energy science 19 = Mechanical engineering 20 = Structural engineering 21 = Transportation engineering

Research Instruments (surveys, interviews, focus groups)

The research instrument (see Table 2 below, for full survey see Appendix D) used is a modified version of the Student Persistence in Engineering Survey developed by Pennsylvania State University and the University of Missouri (AWE, 2023). The modification was the identification of engineering majors that needed to be updated due to the offerings at each university and adding prefer not to answer as an option for gender and race/ethnicity. Assessing Women and Men in Engineering published the persistence in engineering survey with it being made available online for universities to use for research in their engineering colleges. The goal of the survey was to measure students' reasons for persisting in their engineering programs and provide data to universities where they can provide support to increase retention.

Table 2

Student Persisting in Engineering Survey

Question	Responses
Where were you immediately before your first semester/term at this institution?	- High School - 2-year college - 4-year college - Working full time - Military
What was your cumulative GPA at the end of the most recent academic semester/term?	- 1.5-2.0 - 2.0-2.5 - 2.5-3.0 - 3.0-3.5 - 3.5-4.0
Why did you initially decide to major in engineering? (Check all that apply)	- Attracted by the challenge of a difficult curriculum - Good at math or science - High School adviser or teacher recommended - Like to solve problems - Like the design work that engineers do - Participated in an engineering camp or workshop that influenced me - Parents, other relatives, or friends is an engineer

	- Parents, siblings, or other relatives recommended it - Received or anticipated the possibility of a good college scholarship - Wanted to be able to get a well-paying job after I graduate - Wanted to use engineering solutions to address social problems - Took engineering classes in high school and enjoyed them
Check yes or no to indicate if you completed any of these honors or advanced courses during high school.	- Algebra - Biology - Computer Science - Pre-calculus - Calculus - Chemistry - English - Geometry - History - Physics - Trigonometry - Engineering
Do you feel your high school coursework adequately prepared you to be successful in an engineering curriculum?	- Yes - No
What was your unweighted cumulative high school GPA at graduation?	- 1.5-2.0 - 2.0-2.5 - 2.5-3.0 - 3.0-3.5 - 3.5-4.0
What was your ACT score?	- 15-20 - 21-25 - 26-30 - 31-36
When you began your engineering degree, how confident were you that you would complete it? (Check one)	- Not very confident; I was already unsure of my plan to study engineering - I felt there was about a 50% chance that I would complete a degree in engineering - I was fairly confident that I would complete a degree in engineering - I was very confident that I would complete a degree in engineering
At the present time, how confident are you that you will complete a degree (in any major) at this institution? (Check one)	- Not very confident; it is highly unlikely I will not complete an engineering degree - There is about a 50% chance that I will complete a degree in engineering

	- I am fairly confident that I will complete a degree in engineering - I am very confident that I will complete a degree in engineering
The following is a list of engineering activities (co-curricular and academic). For each activity indicate your level of involvement during the most recent academic year (e.g. August to May). (Not Involved, 1-2 times/year, 3-5 times/year, more than 5 times/year).	- An engineering society - An engineering fraternity or sorority - A professional or student group for women or minority engineers - Minority/Multicultural engineering program-sponsored activities - Women in Engineering Program or Women in Science and Engineering sponsored activities - Activities (social or academic) sponsored by your department or major - Design Competition Teams - Undergraduate research experiences - Co-op or Professional Internship position
The following is a list of academic and/or academic preparation activities. Check all the activities in which you engaged during the last academic year (e.g. August to May).	- Attended engineering orientation prior to beginning classes - Attended summer program designed to prepare me to begin the engineering curriculum - Attended review sessions before exams - Called or emailed parents or others about difficulties I was experiencing in classes or school - Got advice from a mentor in a formal mentoring program - Lived in honors or other non-engineering special interest dorm - Participated in engineering-focused living arrangements (dorm, engineering fraternity) - Participated in formal or informal study groups - Received tutoring for courses where I was experiencing difficulty - Scheduled an appointment with a professor and/or graduate assistant outside of his or her office hours - Sought help from other engineering students when I experienced difficulties in classes - Visited a professor and/or graduate assistant in her or his office hours

	- Visited or emailed an adviser or advising center - Visited the Career Center or Co-op office to seek assistance with job search (permanent, internship, or co-op)
Do you currently participate in any college/university athletic activities (intramural or official)?	- Yes - No
Do you work during the academic year?	- Yes - No
When you have an academic problem in engineering, what do you do? (Rank your top 3 choices)	- Do something social or something that relaxes me (exercise, read, etc.) - Form or join a student study group - I never feel this way - Nothing - Seek academic help at a tutoring center - Spend more time studying - Talk to a faculty member - Talk to a mentor - Talk to the engineering adviser and/or advising staff - Talk to other students and/or friends - Talk to my parents or siblings
The following are factors associated with your persisting in your engineering education. For each factor, choose a column ranging from No Influence to Significant Influence to indicate the degree to which that factor influences your persistence in engineering. (no influence, small influence, moderate influence, significant influence)	- Sufficient opportunities for financial aid or scholarships - Engineering faculty/departmental personnel show an interest in me - Reasonable workload of the engineering classes - Friendly climate in engineering classes - Satisfactory performance on my grades in engineering - Faculty help me understand what practicing engineers do - Good teaching by engineering faculty, instructors, or graduate assistants - Effective academic advising by engineering faculty or advisors - Ability to find satisfactory co-ops and/or internships - My personal abilities/talents “fit” the requirements of engineering - Confident of succeeding in engineering future classes - Positive interactions with other engineering students

	- Positive experiences in design teams or other collaborative learning experiences in engineering
How supportive are your parents/guardians in your decision to study engineering?	- Very supportive - Somewhat supportive - Did not have a preference - Somewhat against - Firmly against - Did not discuss the decision

Study Variables

The independent variables in this study are the persistence factors as perceived by the engineering students (pre-college, college, social, and personal factors). The dependent variable is student persistence beyond the first year of engineering school. Additional variables in the data set include gender, race, and ethnicity. The variables were analyzed for the two separate institutions (R2 research and regional university) and then compared to determine similarities and differences. The variables of gender and race/ethnicity were compared to determine similarities and differences.

Data Analysis Procedures (Quantitative Data Analysis Procedures)

Data was analyzed in three separate analyses after completion of the student persisting survey. Initial analysis was conducted for overall persistence factors for both engineering colleges. Frequency and cross-tabulation data analysis was conducted to see themes in the data. Once data was analyzed for persistence factors from the universities a comparison of the data was utilized to see similarities and differences in pre-college, college, and retention programs on persistence at the separate universities. The third analysis was to compare genders and races/ethnicities to see if there were similarities and differences. The purpose of this approach was to answer the research questions for persistence factors related to the different universities, genders, and races/ethnicities.

Statistical analysis that aligns with this study is an independent sample *t* test and an analysis of variance or ANOVA (Ravin, 2020). In a casual comparative (ex post facto) design the use of independent *t* tests and ANOVA tests allowed for the comparison of the two institutions, genders, and races/ethnicities to determine if there are significant differences. The independent *t* tests were used for comparing the two universities and ANOVA tests were used for gender and race/ethnicities since there were more than two. Assumptions with ANOVA needed to be met in this study by making sure no samples were the same and that the populations were approximately the same. Completing the test for homogeneity of the variances helped meet this assumption.

The student persistence in engineering survey responses were collected and analyzed based on the Likert-scale, yes/no, or checking all that applied based on the questions. After obtaining data and analyzing for each institution data was compared between universities using SPSS to compare the means. The independent variables of persistence factors were analyzed to determine the most significant factors contributing to that institution's students' persistence. Using the independent *t* tests and analysis of variance in SPSS the principal investigator determined the *p*-value to not reject or reject the null hypotheses. To compare the two institutions the researcher used SPSS and selected *Analyze* > *Compare Means* > *independent t test* (Yockey, 2018). To compare genders and race/ethnicities the researcher used SPSS and selected *Analyze* > *Compare Means* > *ANOVA* (Yockey, 2018). By completing this analysis, the researcher used Levene’s test for equality of variances to test whether the population variances are equal to ensure the previously mentioned assumption regarding the populations. In the analysis, SPSS produced the effect size which indicated if the effect size was small, medium, or large.

Reliability

The survey completed in this study was administered one time at the two institutions. The consistency of the participant's responses was measured using coefficient alpha or Cronbach’s alpha reliability (Yockey, 2018). The purpose of completing Cronbach’s alpha measure was to see the consistency of participants’ responses by measuring the mathematical equivalent of the means (Yockey, 2018). Determining Cronbach’s alpha in SPSS the researcher selected *Analyze* > *Scale* > *Reliability Analysis* (Yockey, 2018). Once completed *Statistics* under *Descriptives* was selected to determine the reliability of the study (Yockey, 2018). The process was repeated for all data analyzed.

During the research, the principal investigator made sure to be consistent with protocols for administering surveys to students at the two institutions. The survey is also one that has been used and tested at different universities to determine persistence factors. This helps decrease the threat to internal validity by increasing the level of reliability and validity for the research instrument or student persistence in engineering surveys (Ravid, 2020). Not all internal validity was controlled in the study as some differential selection is possible with the difference in the two institutions and comparing the groups (Ravid, 2020). Since the survey is anonymous it allows for a decrease in external validity and allows the research to generalize the study to other colleges of engineering based on demographics (Ravid, 2020).

Chapter IV: Findings and Analysis

The purpose of this study was to investigate the persistence factors as perceived by students at two universities and determine if there are differences based on the university, gender, and race/ethnicity. This chapter represents the findings from the persistence survey. Quantitative data was collected from the persistence survey (Appendix A) emailed to students at the regional and R2 research universities. The survey was emailed to 196 undergraduate engineering students with 27 responses at the regional university and emailed to 1,723 undergraduate engineering students with 25 responses at the R2 research university. At the regional university, 14% responded and at the R2 research university, 2% responded. Quantitative data was analyzed using IBM SPSS. Data was analyzed for descriptive statistics, frequencies, cross-tabulations, analysis of variances, and *t*-tests. Descriptive statistics were analyzed to determine university, gender, race/ethnicity, school year, and engineering major. Frequency and cross-tabulations were used to analyze "check all that apply" and scale questions. This allowed for the identification of themes. Analysis of variances were analyzed to determine if there were significant differences in gender and race/ethnicity persistence factors. To analyze if there were significant differences in university persistence factors *t*-tests were conducted.

Research Questions and Hypotheses

The research questions were developed and modified from the Mara et al., (2012) study except for research question four. The goal of this study was to determine persistence factors among engineering students while also determining if the persistence factors are different depending on university type, gender, and race/ethnicity. The research questions and hypotheses are:

1. What pre-college factors (academic, social, and personal) influence engineering school persistence as perceived by students? How do these differ in an R2 research university compared to a regional university?

    H1: Academic preparation will be the greatest influence on persistence and there will not be a significant difference between the research and regional universities.

2. What college factors (academic, social, and personal) influence engineering school persistence as perceived by students? How do these differ in an R2 research university compared to a regional university?

    H2: Academic factors will have the greatest influence on persistence and there will not be a significant difference between the research and regional universities.

3. What university retention strategies have influenced engineering school persistence as perceived by students? How do these differ in an R2 research university compared to a regional university?

    H3: Mentor strategies will have the greatest influence on persistence and there will not be a significant difference between the research and regional universities.

4. Is there a significant difference in engineering persistence factors among genders and race/ethnicity groups?

    H4: Social factors will be different for genders on engineering persistence factors.

    H5: There will be no difference for race/ethnicity on engineering persistence factors.

Quantitative Sample

Participants were invited to take the persistence survey from the regional and R2 research universities. A total of 27 students at the regional university and 25 students at the R2 research university participated. The gender of the participants included 31 males (59.6%), 17 females (32.7%), and 4 (7.7%) who preferred not to answer (Table 4). Race/ethnicity of the participants included 73.1% White, 7.7% Multiple Races/Ethnicities, 5.8% Asian, 5.8% Black or African American, 5.8% Hispanic or Latino, and 1.9% that preferred not to answer (Table 5).

Table 3

University Frequency

	Frequency	Percent
R2 Research University	25	48.1
Regional University	27	51.9
Total	52	100.0

Table 4

Gender Frequency

	Frequency	Percent
Male	31	59.6
Female	17	32.7
Prefer not to answer	4	7.7
Total	52	100.0

Table 5

Race/Ethnicity Frequency

	Frequency	Percent
Asian	3	5.8
Black or African American	3	5.8
White	38	73.1
Hispanic or Latino	3	5.8
Multiple Races/Ethnicities	4	7.7
Prefer not to answer	1	1.9
Total	52	100.0

The majority of participants were seniors at 50% followed by juniors at 34.6% and sophomores at 15.4% (Table 6).

Table 6

School Year Frequency

	Frequency	Percent
Sophomore	8	15.4
Junior	18	34.6
Senior	26	50.0
Total	52	100.0

The percentage of engineering majors that participated were: 30.8% mechanical engineering, 21.2% civil engineering, 13.5% bioengineering, 7.7% aerospace engineering, 3.8% chemical engineering, 1.9% computer engineering, 1.9% electromechanical engineering, and 1.9% industrial engineering (Table 7).

Table 7

Engineering Major Frequency

	Frequency	Percent
Aerospace Engineering	4	7.7
Bioengineering	7	13.5
Chemical Engineering	2	3.8
Civil Engineering	11	21.2
Computer Engineering	1	1.9
Electrical Engineering	9	17.3
Electromechanical Engineering	1	1.9
Industrial Engineering	1	1.9
Mechanical Engineering	16	30.8
Total	52	100.0

Over three-quarters of the participants were enrolled in the university right after high school while 7.7% attended a two-year college before, 7.7% transferred from another four-year college, 3.8% were working full time, and 1.9% were in the military (Table 8).

Table 8

Previous Location Frequency

	Frequency	Percent
High School	41	78.8
2-year College	4	7.7
4-year College	4	7.7
Working Full Time	2	3.8
Military	1	1.9
Total	52	100.0

Survey Item Analysis

Persistence factors on the survey were Likert Scale from one to four with answer choices of no influence to significant influence. There were seven pre-college questions, 14 academic and social involvement questions, and 13 persistence questions. Cronbach's alpha analysis was used to calculate the reliability of the persistence survey items. The coefficient alpha for the persistence items was 0.870 and when each item was deleted for further reliability analysis the values ranged from 0.854 to 0.883. The means of the individual items ranged from 2.46 to 3.04 (Table 9) with a mean on the total scale of 35.90 and a standard deviation of 8.363. The coefficient alpha of 0.870 indicates a good degree of internal consistency (Yockey, 2018).

Table 9

Mean and Standard Deviation of Persistence Items

	Mean	Std. Deviation
Sufficient opportunities for financial aid or scholarships	2.67	1.098
Engineering faculty/departmental personnel show an interest in me	2.69	1.112
Reasonable workload of the engineering classes	2.46	.999
Friendly climate in engineering classes	2.75	1.100
Satisfactory performance on my grades in engineering	3.00	.886
Faculty help me understand what practicing engineers do	2.60	.934
Good teaching by engineering faculty, instructors, or graduate assistants	2.87	1.067
Effective academic advising by engineering faculty or advisors	2.56	.998
Ability to find satisfactory co-ops and/or internships	2.85	1.195
My personal abilities/talents "fit" the requirements of engineering	3.04	.885
Confident of succeeding in engineering future classes	3.02	.980
Positive interactions with other engineering students	2.92	1.007
Positive experiences in design teams or other collaborative learning experiences in engineering	2.48	1.075

Pre-college Persistence Factors Analysis

Pre-college factors in the survey had participants respond to high school-based questions on the reason they chose engineering as a major, high school engineering participation, GPA, ACT, high school preparation, and high school courses. The hypothesis of academic preparation having the greatest influence on persistence was analyzed through the frequency of respondents. The main reasons students choose to major in engineering include being good at math or science, liking to solve problems, and wanting a well-paying job when they graduate (Table 10).

Table 10

Decision on Engineering Frequencies

		Responses		
		N	Percent	Percent of Cases
Decision on Engineering	Attracted by the challenge of a difficult curriculum	21	8.3%	40.4%
	Good at math or science	42	16.6%	80.8%
	High School adviser or teacher recommended	13	5.1%	25.0%
	Like to solve problems	38	15.0%	73.1%
	Like the design work that engineers do	25	9.9%	48.1%
	Participated in an engineering camp	13	5.1%	25.0%
	Parents other relatives or friends is an engineer	15	5.9%	28.8%
	Parents siblings or other relatives recommended it	16	6.3%	30.8%
	Received scholarship	6	2.4%	11.5%
	Wanted a well-paying job	42	16.6%	80.8%
	Wanted to address social problems	8	3.2%	15.4%
	Took engineering classes in high school	14	5.5%	26.9%
Total		253	100.0%	486.5%

The majority of the students in this study did not take engineering in high school with 61.5% having no experience with engineering before college (Table 11).

Table 11

High School Engineering Participation Frequencies

		Responses		
		N	Percent	Percent of Cases
HS Engineering Participation	PLTW HS Engineering	10	17.2%	19.2%
	Other HS Engineering	5	8.6%	9.6%
	Club HS Engineering	11	19.0%	21.2%
	No HS Engineering	32	55.2%	61.5%
Total		58	100.0%	111.5%

Students entering engineering school have high school GPAs of 3.50 or greater (Table 12) and ACT scores of 26 or higher (Table 13). Over half (57.7%) of the students responded that high school prepared them for engineering school (Table 14).

Table 12

High School GPA

	N	%
2.50-2.99	1	1.9%
3.00-3.49	4	7.7%
3.50-4.00	47	90.4%

Table 13

High School ACT

	N	%
15-20	1	1.9%
21-25	6	11.5%
26-30	21	40.4%
31-36	24	46.2%

Table 14

High School Preparedness

	N	%
Yes	30	57.7%
No	22	42.3%

The majority of the students in the study took multiple AP, honors, or advanced courses except for computer science and engineering (Table 15).

Table 15

High School AP, Honors, or Advanced Courses Frequencies

		Responses		
		N	Percent	Percent of Cases
HS Courses	Algebra	42	10.8%	80.8%
	Biology	32	8.2%	61.5%
	Computer Science	12	3.1%	23.1%
	Pre-calculus	36	9.2%	69.2%
	Calculus	35	9.0%	67.3%
	Chemistry	38	9.7%	73.1%
	English	45	11.5%	86.5%
	Geometry	33	8.5%	63.5%
	History	42	10.8%	80.8%
	Physics	33	8.5%	63.5%
	Trigonometry	31	7.9%	59.6%
	Engineering	11	2.8%	21.2%
Total		390	100.0%	750.0%

College Persistence and Retention Factors Analysis

Students entering college were fair to very confident in completing their degree but after being in engineering school 82.7% now are very confident in degree completion (Table 16).

Table 16

Confidence in Degree Completion Frequencies

	Beginning Confidence	Present Confidence
Not Very Confident	3.8%	0%
50% Chance of Degree Completion	9.6%	1.9%
Fairly Confident	40.4%	15.4%
Very Confident	46.2%	82.7%

Of the items listed in the survey, most of the respondents indicated no involvement in the majority of the activities. Engineering society (55.8%), social or academic activities sponsored by the department (63.4%), and co-op or internship (69.3%) did show higher than 50% involvement throughout the year (Table 17).

Table 17

College Activities Frequencies

	Not Involved	1-2 times per year	3-5 times per year	5 or more times per year
Engineering Society	44.2%	26.9%	13.5%	15.4%
Engineering Fraternity or Sorority	90.4%	1.9%	0%	7.7%
Women or Minority Groups	78.8%	11.5%	1.9%	7.7%
Minority Sponsored Activity	88.5%	5.8%	1.9%	3.8%
Women in Engineering Activity	73.1%	11.5%	3.8%	11.5%
Social or Academic Activity Sponsored by the Department	36.5%	34.6%	11.5%	17.3%
Design Competition Teams	82.7%	7.7%	5.8%	3.8%
Undergraduate Research	71.2%	15.4%	5.8%	7.7%
Co-op or Internship	30.8%	48.1%	5.8%	15.4%

When students prepare for the academic rigors of engineering school they indicate forming study groups (57.7%), seeking out help from other engineering students (80.8%), visiting their professor during office hours (76.9%), and visiting their advisor (55.8%) as most helpful (Table 18).

Table 18

Academic Preparation Activities Frequencies

		Responses		Percent of
		N	Percent	Cases
Academic Preparation Activities	Engineering Orientation	10	3.8%	19.2%
	Summer Bridge	3	1.1%	5.8%
	Review Sessions before exams	23	8.8%	44.2%
	Called Parents about difficulty	20	7.7%	38.5%
	Mentor Advice	8	3.1%	15.4%
	Honors Dorm Living	9	3.4%	17.3%
	Engineering Dorm Living	8	3.1%	15.4%
	Study Groups	30	11.5%	57.7%
	Tutoring	12	4.6%	23.1%
	Visited professor outside office hours	17	6.5%	32.7%
	Sought help from other engineering students	42	16.1%	80.8%
	Visited professor during office hours	40	15.3%	76.9%
	Visited advisor	29	11.1%	55.8%
	Visited career center	10	3.8%	19.2%
Total		261	100.0%	501.9%

The majority of students are not involved with athletic participation but the majority do work (Table 19).

Table 19

Athletic and Work Involvement Frequencies

	Athletic Participation	Work Participation
Yes	32.7%	59.6%
No	67.3%	40.4%

As students struggle academically their solutions involve doing something social (57.7%), spending more time studying (65.4%), and talking to other students or friends (84.6%) (Table 20).

Table 20

Academic Problem Solution Frequencies

		Responses		Percent of
		N	Percent	Cases
Academic Problem Solution	Do something social	30	17.0%	57.7%
	Study group	11	6.3%	21.2%
	I never feel this way	1	0.6%	1.9%
	Nothing	10	5.7%	19.2%
	Seek academic help through tutoring	5	2.8%	9.6%
	Spend more time studying	34	19.3%	65.4%
	Talk to a faculty member	18	10.2%	34.6%
	Talk to a mentor	3	1.7%	5.8%
	Talk to engineering advisor	11	6.3%	21.2%
	Talk to other students or friends	44	25.0%	84.6%
	Talk to parents or siblings	9	5.1%	17.3%
Total		176	100.0%	338.5%

The large majority (88.4%) of engineering students indicate that parental support is somewhat to very supportive (Table 21).

Table 21

Parent Support Frequencies

	N	%
Very Supportive	41	78.8%
Somewhat Supportive	5	9.6%
Did not have a preference	3	5.8%
Did not discuss the decision	3	5.8%

Students that persist in engineering indicate financial opportunities (57.6%), faculty showing interest (57.7%), friendly climate (63.5%), satisfactory performance on grades (69.2%), good teaching (67.3%), effective advising (53.8%), finding co-ops or internships (59.6%), abilities “fit” engineering (75%), confidence in succeeding (69.2%), positive interactions with other engineering students (65.3%), and positive collaborative learning experiences (50%) as moderate to significant influence on persistence (Table 22).

Table 22

Persistence Factors Frequencies

	No Influence	Small Influence	Moderate Influence	Significant Influence
Financial Opportunities	19.2%	23.1%	28.8%	28.8%
Faculty Showing Interest	19.2%	23.1%	26.9%	30.8%
Reasonable Workload	19.2%	32.7%	30.8%	17.3%
Friendly Climate	19.2%	17.3%	32.7%	30.8%
Satisfactory Performance on Grades	3.8%	26.9%	34.6%	34.6%
Faculty Helping Understand What Engineers Do	11.5%	36.5%	32.7%	19.2%
Good Teaching	15.4%	17.3%	32.7%	34.6%
Effective Advising	17.3%	28.8%	34.6%	19.2%
Finding Co-ops or Internships	19.2%	21.2%	15.4%	44.2%
Abilities “fit” engineering	5.8%	19.2%	40.4%	34.6%
Confidence in Succeeding	7.7%	23.1%	28.8%	40.4%
Positive Interactions with other Engineering Students	9.6%	25.0%	28.8%	36.5%
Positive Experience in Collaborative Learning Experiences	23.1%	26.9%	28.8%	21.2%

University Data Analysis

For the first three research questions on engineering persistence related to pre-college factors, college factors, and retention strategies the researcher used the independent-sample *t* test to determine if there was a significant difference between the regional and R2 research universities. Levene's test for equality of variances was used to determine if equal variances were assumed or not assumed to determine what *p*-value to interpret. If $p \leq .05$ the researcher assumed the variances were not equal and if $p > .05$ the variances were assumed equal (Yockey, 2018).

Pre-college factors analyzed were decisions on majoring in engineering, high school courses, high school engineering participation, high school adequately prepared for college perception, high school GPA, and high school ACT. The survey item of receiving a scholarship on the decision to major in engineering was significant with $p = .006$ indicating there is a difference in the regional and R2 research universities. The R2 research university had more students indicate that receiving a scholarship influenced their decision on choosing to major in engineering. All other survey items for their decision to major in engineering had $p > .05$ indicating no significant difference. Calculus ($p = .012$) and history ($p = .006$) high school classes were significant with higher means at the R2 research university. High school engineering participation was not significant, with $p > .05$ for the survey items indicating no difference in the universities. Students' perception of high school preparing them for college was not significant, with $p = .386$ indicating no difference in the universities. Both high school GPA and ACT were significant, with $p = .031$ and $p = .047$. High school GPA was higher at the regional university while high school ACT was higher at the R2 research university.

College and retention factors analyzed were beginning and present level confidence in completing their degree, engineering activities involvement, academic preparation activities, athletic involvement, work involvement, academic problem solutions, parent support, and persistence factors. Beginning confidence was significant with more students from the regional university being very confident in completing their degree, with $p = .035$. Present level of confidence was not significant, with $p = .218$. All survey items for engineering activities involvement were not significant with $p > .05$. The following academic preparation activities were significant: attended review sessions before exams ($p = .028$), participated in engineering-focused living arrangements ($p = .003$), participated in formal or informal study groups ($p = .001$), and visited the career center or co-op office to seek assistance with job search ($p = .024$). Attending review sessions, participating in engineering-focused living arrangements, participating in formal or informal study groups, and visiting the career center were all higher for the R2 research university. Athletic and work involvement was not significant, with $p = .062$ and $p = .958$. Solutions to academic problems were significant for seeking academic help or tutoring ($p = .023$), spending more time studying ($p = .033$), talking to other students and/or friends ($p = .029$), and talking to parents or siblings ($p = .014$). Seeking academic help through tutoring and talking to parents or siblings were higher for the regional university while spending more time studying and talking to other students or friends was higher for the R2 research university. Parent support was significant, with $p = .033$ indicating a higher level of parent support at the regional university. Persistence factors were significant for engineering faculty showing interest ($p <.001$), friendly climate ($p = .013$), and effective advising ($p = .026$). Faculty showing interest, friendly climate, and effective advising were all higher at the regional university.

Gender Data Analysis

When determining significance for gender the researcher conducted an analysis of variance since there were three options (male, female, prefer not to answer). Pre-college, college, and retention factors were analyzed to determine if there was significance with engineering persistence and gender.

There was no significance for pre-college factors of ACT, GPA, and being prepared academically for college with $p > .05$ for gender (Table 23).

Table 23

Significance Level for Pre-College Factors for Gender

	p-value	Significant
ACT	0.812	No
GPA	0.193	No
Prepared for College	0.136	No

Parental support was significant, with $p = .003$ (Table 24). Students who preferred not to answer for gender had a higher level of not discussing the decision with a parent.

Table 24

Significance Level for College Factors for Gender

	p-value	Significant
Beginning Confidence	0.588	No
Present Confidence	0.757	No
Athletic Involvement	0.594	No
Work Involvement	0.175	No
Parental Support	0.003	Yes

Undergraduate research involvement was significant, with $p = .037$ (Table 25). Females were more involved with undergraduate research more times throughout the year than males or those who preferred not to answer for gender.

Table 25

Significance Level for College Activity Factors for Gender

	p-value	Significant
Engineering Society	0.318	No
Engineering Fraternity or Sorority	0.721	No
Women or Minority Student Group	0.293	No
Minority Program	0.578	No
Women Program	0.203	No
Social or Academic Activities	0.059	No
Design Competition Teams	0.400	No
Undergraduate Research	0.037	Yes
Co-op or Internship	0.575	No

Satisfactory performance on grades was significant, with $p < .001$ (Table 26). More females indicated a moderate to significant influence compared to males and preferred not to answer. Males indicated a small to moderate influence.

Table 26

Significance Level for Persistence Factors for Gender

	p-value	Significant
Financial Opportunities	0.144	No
Faculty Showing Interest	0.175	No
Reasonable Workload	0.300	No
Friendly Climate	0.396	No
Satisfactory Performance on Grades	<0.001	Yes
Faculty Helping Understand What Engineers Do	0.761	No
Good Teaching	0.147	No
Effective Advising	0.721	No
Finding Co-ops or Internships	0.370	No
Abilities "fit" engineering	0.516	No
Confidence in Succeeding	0.404	No
Positive Interactions with other Engineering Students	0.306	No
Positive Experience in Collaborative Learning Experiences	0.976	No

Race/Ethnicity Data Analysis

When determining significance for race/ethnicity the researcher conducted an analysis of variance since there were eight options. Pre-college, college, and retention factors were analyzed to determine if there was significance with engineering persistence and race/ethnicity.

There was no significance for pre-college factors of ACT, GPA, and being prepared academically for college with $p > .05$ for race/ethnicity (Table 27).

Table 27

Significance Level for Pre-College Factors for Race/Ethnicity

	p-value	Significant
ACT	0.786	No
GPA	0.088	No
Prepared for College	0.919	No

Parental support was significant, with $p < .001$ (Table 28). Hispanic or Latino indicated a higher level of not having a preference concerning parental support.

Table 28

Significance Level for College Factors for Race/Ethnicity

	p-value	Significant
Beginning Confidence	0.046	Yes
Present Confidence	0.673	No
Athletic Involvement	0.058	No
Work Involvement	0.261	No
Parental Support	<0.001	Yes

Minority engineering program-sponsored activity and women in engineering program activity were both significant, with $p = .016$ and $p = .035$ (Table 29). Asian and Black or African Americans were more involved with minority engineering program-sponsored activities. Asian, Black or African American, and White were more involved with women in engineering program activities.

Table 29

Significance Level for College Activity Factors for Race/Ethnicity

	p-value	Significant
Engineering Society	0.477	No
Engineering Fraternity or Sorority	0.919	No
Women or Minority Student Group	0.148	No
Minority Program	0.016	Yes
Women Program	0.035	Yes
Social or Academic Activities	0.726	No
Design Competition Teams	0.138	No
Undergraduate Research	0.208	No
Co-op or Internship	0.342	No

A student's perception of their personal abilities "fit" the requirements of engineering was significant, with $p = .022$ (Table 30). White had a higher moderate to significant influence on their perception of personal abilities that "fit" engineering.

Table 30

Significance Level for Persistence Factors for Race/Ethnicity

	p-value	Significant
Financial Opportunities	0.352	No
Faculty Showing Interest	0.874	No
Reasonable Workload	0.505	No
Friendly Climate	0.680	No
Satisfactory Performance on Grades	0.075	No
Faculty Helping Understand What Engineers Do	0.217	No
Good Teaching	0.711	No
Effective Advising	0.566	No
Finding Co-ops or Internships	0.596	No
Abilities "fit" engineering	0.022	Yes
Confidence in Succeeding	0.065	No
Positive Interactions with other Engineering Students	0.719	No
Positive Experience in Collaborative Learning Experiences	0.193	No

Summary

There were major themes from this study for pre-college, college, and retention factors including differences in the two universities, gender, and race/ethnicity. These findings are represented by students who have persisted in engineering. Students who choose engineering are good at math or science, like to solve problems, and want a well-paying job when they graduate. High GPA, ACT scores, and multiple AP, honors, or advanced classes in high school are important for engineering. Having previous experience with engineering through clubs or engineering classes in high school does not indicate persistence.

Involvement in an engineering society, social or academic activities sponsored by the department, and co-op or internship increase persistence. Forming study groups, seeking out help from other engineering students, visiting a professor during office hours, and visiting an advisor are helpful for students to prepare for the academic rigor of engineering school. When students struggle academically their solutions involve doing something social, spending more time studying, and talking to other students or friends. Parental support is also important for engineering persistence. Financial opportunities, faculty showing interest, friendly climate, satisfactory performance on grades, good teaching, effective advising, finding co-ops or internships, abilities “fit” engineering, confidence in succeeding, positive interactions with other engineering students, and positive collaborative learning experiences are indicators of persistence.

University differences between the R2 research and regional universities include pre-college and college factors. The R2 research differences for pre-college include receiving scholarships, high school calculus, and history courses, and ACT scores while the regional university is GPA. College factors for the R2 research university include academic preparation (review sessions, engineering-living dorms, study groups, career center for co-op), and academic solutions (studying more, talking to other students). Regional university college factors include beginning confidence, academic solutions (attending tutoring, talking with parents or siblings), parental support, and persistence (showing interest, friendly climate, effective advising).

Some differences were indicated for gender and race/ethnicity in student persistence. Gender included a significance in parental support, undergraduate research involvement, and satisfactory grades. Parental support difference was with students who preferred to not indicate their gender and not discussing the choice of majoring in engineering with their parents. Females were more involved with undergraduate research and their grades significantly impacted their persistence. Race/ethnicity included parental support, minority program events, women in engineering events, and personal abilities that "fit" engineering. Hispanic or Latino indicated they had no preference for parental support with engineering. Asian and Black or African Americans are more involved with minority program events. Asian, Black or African American, and White are more involved with women in engineering programs. White students feel their personal abilities "fit" engineering more significantly than other students.

Chapter V: Conclusions and Discussion

Engineering retention has continued to be an issue at universities with between 40% and 50% of engineering students choosing to change majors or drop out before graduation (Charboneau, 2020). Additionally, engineering colleges have seen a decrease in enrollment even though there is a high demand for engineers (Hughes et al., 2019). This decrease in enrollment and low persistence rates has caused a need for more engineers to meet industry needs (Cole, 2013; Desai & Stefanek, 2017).

Until recently, most research in retention and persistence has focused on general university needs. Some recent studies have looked specifically at engineering colleges with limited research on the type of institution, gender differences, and race/ethnicity differences. The purpose of this study was to investigate engineering persistence factors at a regional university and an R2 research university and compare differences in the universities as well as differences in gender and race/ethnicity. Significant persistent factor themes for the type of university, gender and race/ethnicity, P-20 implications, limitations of the study, and recommendations for future research on engineering retention/persistence are discussed in this chapter.

Conclusions and Relationship to Research

The quantitative analysis of the four research questions for engineering persistence provides great detail into the differences between the two universities and differences in gender and race/ethnicity. Key findings indicate that some persistence factors are dependent on the type of university, the gender of the individual, and the race/ethnicity of the individual. This study supported previous studies in some areas of engineering persistence while also providing additional indicators of pre-college, college, and retention factors.

Pre-college

The choice a student makes to major in engineering has a significant influence on engineering school persistence, with specific factors playing a role in the students' decisions. Motivations include proficiency in math or science, a passion for problem-solving, and wanting a well-paying job and career post-graduation. Veenstra et al. (2009) cited quantitative skills and confidence as reasons students choose engineering and their persistence in engineering. The researcher found that 80.8% of students indicated proficiency in math or science as a reason they decided to major in engineering agreeing with the study by Veenstra et al. (2009). Problem-solving, which is another indicator of student persistence in a study by Hughes et al. (2019), was identified by 73.1% of students in this study. The possibility of a high post-graduation salary also influenced 80.8% of students on their decision to major in engineering, identifying the impact future finance has on engineering major selection.

High school academic performance measures, specifically GPA and ACT scores, are significant predictors of engineering school persistence. A high school GPA of 3.50 or higher was reported by 90.4% of students, while an ACT score of 26 or higher was indicated by 86.6%. Previous studies have identified high school GPA and ACT scores as significant predictors of engineering persistence (French et al., 2005; Geisiner & Raj Raman, 2013; Hall et al., 2015; Honken & Ralston, 2013; Moses et al., 2011; Veenstra, 2009). Adequate preparation through challenging high school coursework is important due to the rigorous curriculum in engineering and over 50% of the students in this study participated in advanced placement, honors, or advanced courses in algebra, biology, pre-calculus, calculus, chemistry, English, geometry, history, physics, and trigonometry. Advanced math courses, particularly calculus, have been identified in multiple studies as strong predictors of engineering persistence, reinforcing the findings from this study and the importance of high school academic preparation (Geisinger & Raj Raman, 2013; Hall et al., 2015; Honken & Ralston, 2013; Tyson, 2011; Veenstra, 2009).

Research findings on the impact of high school pre-engineering programs on college engineering persistence have conflicting results. Some studies found increased persistence when students have previous experience through high school pre-engineering programs, others indicated similar rates to general students (Cole, 2013). In this study, only 21.2% of students reported taking pre-engineering and 23.1% reported taking computer science in high school and overall only 21.2% reported participation in engineering clubs. 61.5% of students had no prior experience with engineering through either high school classes or clubs before college, suggesting the effectiveness of pre-engineering programs may vary from what has been identified in previous research.

College and Retention

A student's confidence in completing their engineering degree plays a critical role in their persistence to degree completion. In this study, there was a trend that emerged indicating confidence changing throughout engineering school. Initially, 86.6% of participants expressed confidence in their ability to finish their engineering degree which is a high degree of confidence. However, as students progressed through engineering school there was a shift in their confidence level with an increase to 98.1%. Hughes et al. (2019) identified engineering identity, or the confidence students have in being an engineer and seeing themselves as an engineer, plays a crucial role in engineering persistence.

This shift in student's confidence is a crucial aspect of engineering school persistence. Previous research findings and findings from this study highlight the connection between confidence and academic persistence. Students who maintain a positive outlook regarding their ability to complete an engineering degree, both before beginning and throughout their time in engineering school have a higher likelihood of persisting to graduation.

Academic support strategies

Students in engineering will face academic challenges due to the rigorous curriculum and the way students adjust to those challenges influences their persistence. In this study, the strategies identified by students include forming study groups (57.7%), seeking help from peers and professors (80.8%), consulting advisors (55.8%), spending more time studying (65.4%), and talking to other students or friends (84.6%). Hall et al. (2015) concluded that college GPA is the sole predictor of a student's persistence in engineering. Additional studies have also indicated that cumulative GPA is the primary contributor to a student's persistence (French et al., 2005; Jackson et al., 1993; Veenstra et al., 2008). The findings on academic support from this study align with previous research but also build upon previous findings by indicating factors such as forming study groups, seeking help from peers and professors, and spending more time studying as academic support. These supports will allow students to perform better and have a higher GPA contributing to persistence.

Involvement and Engagement

The research findings on the impact of involvement and engagement on engineering school persistence agreed with previous research in some areas. While previous research has identified multiple areas of involvement, the findings in this study showed students were actively engaged in engineering societies, participated in co-ops or internships, and were involved in various social and academic activities. Students did identify involvement across other areas but in smaller participation than in previous research studies.

Students reported they were involved with engineering societies (55.8%) and 63.4% indicated they were involved in various social and academic activities. These findings show the significance of involvement and engagement as a predictor of persistence. This aligns with Tinto's (1975, 1993) integration theory and Astin's (1999) research, which emphasizes the significance of both social and academic integration for student persistence. An involved and engaged student is important in having the support needed to persist in engineering.

Participation in co-ops or internships emerged as another factor contributing to engineering persistence. Co-op or internship involvement was identified by 69.3% of the students. These experiences likely provide students with real-world applications that could enhance their understanding and motivate them to persist. Lin (2017) and Hughes et al. (2019) findings agree with this research, indicating the important role co-ops and internships play in retaining students and helping them persist to graduation.

Institutional and classroom climate

The “chilly climate hypothesis,” described by Daempfle (2002) as an unwelcoming atmosphere in engineering that has an unapproachable faculty, a demanding curriculum, and a lack of support and encouragement is a significant predictor of students’ persistence. Santiago & Hensel (2012) and Kuley et al. (2015) support the chilly climate hypothesis by showing that positive faculty interactions and institutional climate are factors that contribute to students' likelihood of persisting in engineering. In this study, 63.5% of students value a friendly climate, 57.7% emphasize the faculty showing personal interest in them, 67.3% indicate the importance of good teaching from faculty, and 53.8% indicate effective advising as reasons for persistence.

Marra et al. (2012) identified poor teaching, faculty interactions, classroom climate, and difficult curriculum as primary reasons for students to not persist. Meyer and Marx (2014) included advisor interaction, with students reporting feeling discouraged from persisting in engineering due to the cold climate and unsupportive advisors. These findings, including previous research, indicate the critical role a supportive institutional and classroom climate play in persistence.

Social Factors

Tinto's (1975, 1993) integration theory and Astin's (1999) research emphasized the importance and significance of both social and academic integration for student persistence. Social factors in this study revealed that when students face academic challenges 84.6% turn to peers or friends for support, 78.8% value peer and parental support, 57.7% engage in social activities, 65.3% indicate positive interactions with fellow engineering students, and 50% emphasize positive collaborative learning experiences. These findings align with previous research and the importance for students to develop strong social networks in engineering persistence.

Hughes et al. (2019) support these findings by identifying positive social engagement as a predictor of engineering persistence. On the opposite side, Veenstra (2009) recognized social disengagement, due to the demanding nature of engineering courses, as a reason students do not persist. Social engagement can come from a variety of ways such as social activities, peers, and parental support which indicates the importance of a student developing a strong social support network. These findings, along with previous research, support the importance of social engagement when students are faced with academic challenges so students persist to graduation.

Personal Factors

Recent research has focused on personal factors and their contribution to persistence in engineering. Personal factors have been shown in research to play a role in students' persistence and students in this study indicated similar frequencies. Self-efficacy or a student's confidence in being successful had a frequency of 69.2% and 75% indicated engineering identity or the belief that their abilities "fit" engineering as persistence factors. These personal factors are crucial aspects of influencing a student's decision to persist in engineering.

The correlation between self-efficacy and academic performance has been shown with previous research indicating a decrease in self-efficacy from low grades or failures in prerequisite engineering courses like calculus (Geisinger & Raj Raman, 2013; Meyer & Marx, 2014). Female students with lower self-efficacy have been shown to drop out or change majors at higher rates (Kuley et al., 2015). An increase in self-efficacy through positive faculty relationships helps increase GPA and persistence (Geisinger & Raj Raman, 2013). Friendly climate (63.5%), faculty showing personal interest (57.7%), and good teaching (67.3%) were shown in this study to contribute to persistence which could also be factors in self-efficacy. The frequencies reported in this study reinforce the importance of self-efficacy in engineering persistence.

Engineering identity has come to light in more recent research and has shown to be important for all engineering students and their persistence. Marra et al. (2012) and Hughes et al. (2019) indicated the significance of engineering identity in persistence which aligns with the findings in this study. Students felt that their abilities "fit" engineering as a career and contributed to their persistence as indicated with a frequency of 75%. Engineering identity plays a crucial role in a student's sense of belonging which significantly impacts their decision to persist to graduation (Geisinger & Raj Raman, 2013; Marra et al., 2012; Hughes et al., 2019).

Retention

Co-op and internship involvement (69.3%) were indicated to be one of the most influential factors contributing to student persistence in this study, aligning with previous research findings that show the positive impact they have on retention (Lin, 2017; Hughes et al., 2019). Other retention strategies had mixed results in this study in comparison to previous research. Tutoring, mentorship programs, learning-living communities, and summer bridge programs showed different degrees of frequency compared to the previous findings.

Tutoring had a frequency of only 23.1% despite the benefits of helping students feel connected to the university and supporting them for persistence to graduation (Graffigna et al., 2013). Mentorship programs have been shown in research to be successful in persistence, particularly for minority and female students, (Kuly et al., 2015; Wang et al., 2022) had a frequency of 15.4%. Learning-living communities in engineering have been reported to increase retention through improved grades, improved self-efficacy, and greater confidence in math and science abilities (Geisinger & Raj Raman, 2013) but only had a 15.4% frequency in this study. Summer bridge programs did align with previous research with only 5.8% indicating involvement for persistence (Cancado et al., 2018).

These findings indicate the importance of retention strategies specific to the university and the needs of engineering students. While co-op and internship involvement are highly effective, in previous research and this study, other findings of retention strategies vary. This understanding of retention strategies to support persistence is important and should be studied at each university to support the needs of their engineering students.

University Comparison

Comparing universities for differences in engineering persistence has limited research and an area this research helps to fill the gap. These findings are valuable in the understanding of the unique factors that influence student's persistence at different institutions. At the regional university, pre-college persistence factors showed a significant association with high school GPA ($p = .031$), indicating the relevance of academic preparedness before entering college. College factors contributing to persistence were significant for initial confidence levels ($p = .035$), parental support ($p = .033$), effective academic solutions with tutoring ($p = .023$), and communication with parents ($p = .041$). Persistence indicators included the faculty showing personal interest in students ($p < .001$), a friendly institution and classroom climate ($p = .013$), and effective engineering advising ($p = .026$). The findings for the regional university emphasize the importance of high school GPA, initial confidence toward graduation, family support, tutoring, faculty connection, effective advising, and a positive climate for engineering persistence.

In contrast, the R2 research university had pre-college persistence factors including receiving scholarships ($p = .006$), involvement in high school calculus ($p = .012$) and history ($p = .006$) classes, and high school ACT score ($p = .047$). College factors included academic preparation through review sessions ($p = .028$), living in engineering-specific arrangements ($p = .003$), forming study groups ($p = .001$), and seeking co-op assistance at the career center ($p = .024$). Significant solutions to academic challenges included studying more ($p = .033$) and having conversations with other students ($p = .029$). These findings for the R2 research university emphasize the importance of receiving scholarships and high school preparation through advanced calculus and history classes along with a high ACT score on pre-college influence on persistence. Additionally, attending review sessions, living in engineering dorms, forming study groups, studying more, engaging in discussions with other students, and getting co-op assistance are important college factors with engineering persistence.

These findings provide insight into the importance of universities looking at specific persistence factors based on their type of university. At the regional university, there is more of an emphasis on the institutional and classroom climate indicating students look to the smaller and more connected institution in persistence. There is also significance in students entering college with a high GPA and having an initial confidence in degree completion. At the R2 research university, there is more of an emphasis on social aspects of college for persistence through study groups, review sessions, living arrangements, and talking with other students when they struggle. There is also significance in pre-college factors placed on scholarship opportunities, a high ACT score, and academic preparation through calculus.

Gender Comparison

While examining the significance of the influence of gender on engineering school persistence, the findings indicated variations across different categories. Males did not exhibit significant indicators for differences among the factors for persistence. Individuals who preferred not to answer their gender had significance with parental support ($p = .003$), indicating they did not discuss their decision with their parents. Females showed a higher rate of involvement in undergraduate research ($p = .037$) and satisfactory grades in engineering courses playing a significant role in influencing their persistence ($p < .001$) compared to other gender categories.

Previous research has identified the challenges faced by females in a male-dominated major and profession. Studies have indicated females leave engineering at higher rates, often due to issues related to engineering identity (Geisinger & Raj Raman, 2013; Hughes et al., 2019). In an early study by Jackson et al. (1993) they identified self-perception of abilities as contributing to female student persistence. Kuley et al. (2015) showed that committed female students with high self-efficacy demonstrated resilience and contributed to a sense of engineering identity. This study highlights the importance of involvement and satisfactory grades for female students which could help increase their self-perception and engineering identity as indicated in previous research.

Race/Ethnicity Comparison

Similar to gender, when examining the significance of race and ethnicity on engineering school persistence, the findings indicated variations across different categories. Among the eight identified groups, specific significant factors for persistence emerged. Hispanic and Latino students indicated no preference in deciding on majoring in engineering ($p < .001$). Asian and Black or African American students indicated higher involvement in minority activity programs ($p = .016$) compared to the other races and ethnicities. Asian, Black or African American, and White students were more involved in women in engineering activity programs ($p = .035$). A significant association between engineering identity or a student's perception of themselves as a good fit in engineering was indicated for White students compared to other races and ethnicities ($p = .022$).

Although mentorship programs for minority students did not show significance for engineering persistence, previous research has indicated the benefits due to lower self-efficacy (Kuley et al., 2015). Wang et al. (2022) indicated mentorship initiatives specifically for minorities as beneficial for the retention of students. The findings in this study showed significance for White students' perception of themselves or their engineering identity. This indicates other races and ethnicities have lower self-efficacy or engineering identity which does align with previous research. Even though this study did not have significance for mentor programs for minority students, programs such as mentorships that help increase self-efficacy could play a role in minority student's persistence.

Discussion

This quantitative analysis of the four research questions exploring engineering persistence gives insight into the differences between universities, genders, and races/ethnicities. The findings from this study not only contribute to the understanding of individual factors influencing engineering persistence but also implications for high schools and engineering schools at different universities.

Pre-college factors such as math or science proficiency and problem-solving skills indicate the important factors that influence students toward engineering majors. High school GPA, ACT scores, and multiple AP, honors, or advanced courses are critical indicators of academic preparedness for engineering programs. There are conflicting findings regarding the impact of pre-engineering programs suggesting high schools should align their pre-engineering programs with rigorous curricula and other academic courses. These pre-college factors indicate the role of high schools in student's academic preparedness so they are ready for the rigor of engineering.

College factors indicate the significance of confidence in degree completion, academic support strategies, and involvement in co-ops/internships. Quality of teaching, faculty interactions, and the institutional climate are critical factors influencing student persistence which suggest the need for engineering schools to provide a positive institutional and classroom climate. Additionally, there is importance with social engagement and engineering schools should look to foster social activities to help students build community and increase the positive climate.

Universities should spend time identifying specific factors for their engineering schools that contribute to persistence. In this study, the R2 research university and the regional university had specific factors that contributed to their student's persistence. Part of the research questions for this study was to determine if different factors depend on university type and the findings suggest there are. Along those same lines, there are different persistence factors for gender and race/ethnicity that engineering schools should be aware of and place importance on retention strategies for specific groups to support persistence.

Practical Significance

Improving student retention and persistence to graduation is important for engineering schools and the world. With engineering school enrollment declining, the number of engineers graduating, and the increased need for engineers around the world there should be value placed on the importance of universities to increase student retention. By looking at the reasons students persist or drop out of engineering programs, researchers and universities can provide practical solutions to improve student persistence. Providing appropriate support could ensure increased enrollment and graduation which would help with the current shortage of engineers.

High schools should look into providing an appropriate curriculum for students to be successful in entering engineering school. While pre-engineering programs have been shown to have mixed results, they could be paired appropriately with other challenging courses which could improve a student's engineering identity or their confidence in going into engineering. Supporting students to improve their GPA and ACT scores would also help improve their academic preparedness for engineering school.

Engineering schools should look at improving the institutional and classroom climate to support student's success and persistence. Improving a hands-on curriculum that is a supportive learning environment with faculty supporting and connecting with students would improve persistence. Providing social engagement activities specific to engineering would additionally reduce the “chilly climate” in engineering to foster a more collaborative environment. It would be important that universities look at their needs in improving institutional and classroom climate as this study indicated there are differences in university type and needs. Additionally, engineering schools should look at their demographics and the needs of different genders and races/ethnicities so support can be provided for those students.

P-20 Implications

This study on engineering persistence with a focus on differences in university type, gender, and race/ethnicity outlines the significant importance of engineering education across P-20. The typical siloed nature of the education system and the world, particularly the disconnect between high school to college, presents a challenge that needs to be addressed and this research hoped to fill part of that gap. With the decreased enrollment in engineering schools, a limited number of engineers graduating, and the shortage of engineers there should be an increased importance placed on research to address the silos.

Secondary education should improve communication and connection with universities to make sure students are better prepared to enter college. Findings indicated that students should take advanced courses, have a high GPA, and high ACT score to be successful in engineering school. Since university type plays a role in the specific persistence factors it is important that high schools stay connected through partnerships with all local universities to provide the support needed for student success. With the additional understanding of the challenges minorities and females face, high schools need to provide the support that will improve self-efficacy to support the transition from high school to college. High school pre-engineering programs should partner with local engineering schools to better prepare students and increase their self-efficacy or engineering identity before entering college. This could also be built through mentor programs with local engineering professionals. These recommendations break down the silos from high schools to colleges and the future workforce.

At the postsecondary level, there should be an assessment of recruitment and admissions to connect with the local community. Having targeted goals to address recruitment and support of K-12 in the local community through STEM or engineering camps would help bridge this gap. Mentor programs specific for gender and minorities that are included in these camps would help improve future students' confidence in engineering which this research shows to be beneficial in persistence. Co-op and internship involvement early in college with engineering professionals would also be beneficial in breaking down silos and providing additional support for students. This collaboration between universities and engineering industries would help in promoting co-op and internship opportunities for students further breaking down the silos from college to the workforce.

P-20 implications from this study indicate the importance of addressing the fragmented nature of the educational system and its connection to the world. Additional research to address these issues would help foster a more collaborative experience for engineering education and other stakeholders. There is potential to bring about positive changes in engineering education from these P-20 implications that would contribute to a more supportive environment for persistence and address the issue of the lack of engineers.

Limitations

Despite the insights from this study on engineering persistence, some limitations impact the validity and generalizability of the findings. The limited generalizability of this study is a challenge as the results may not be applicable beyond the two universities studied. While the goal of the study was to investigate an R2 research university compared to a regional university not all of these types of universities have the same characteristics such as their demographics. This restriction limits the ability of this study to inform engineering schools with differing characteristics.

Survey data has specific limitations such as self-selection bias, recall bias, social desirability bias, limitations in providing in-depth understanding, and limited ability to establish causality. Self-selection bias is possible due to students who choose to respond to the survey being different from those who choose not to participate. Recall bias is possible as students may struggle to accurately recall their experiences on persistence factors. This could increase as a student moves from year to year and looks back on factors that contributed to their persistence. Social desirability bias could be possible as students may provide responses perceived as socially desirable compared to expressing their true opinions. Surveys do not provide the depth that a qualitative study provides which leads to the limitation of lack of in-depth understanding. Causality is also difficult to determine based on survey data and is difficult to provide a definitive conclusion about relationships between persistence factors, university type, gender, and race/ethnicity.

The length of the study and sample size are additional limitations. The survey was open for a two-week window during the spring semester which provides only a snapshot of a student's experience. This limits the longer-term trends in persistence factors over time. The small sample size was also limited due to the number of responses from the two universities. While the sample size meets the requirements for appropriate quantitative research an analysis of the sample by gender and race/ethnicity has potential limitations, especially with the regional university and the smaller diversity.

Recommendations for Future Research

College engineering persistence is multifaceted and future research should consider the various dimensions to help understand the challenges and in providing solutions. These include longitudinal studies, analysis of different demographics, analysis of different university types, qualitative research, research on transition points, pre-engineering curriculum, faculty perspectives, curriculum and teaching approaches, and long-term outcomes. While this study helped to fill the gap in some of these areas for engineering persistence these recommendations for future research would help positively contribute to engineering education.

A longitudinal study that includes an analysis of different types of universities and different demographics would contribute to an understanding of students over an extended period. Tracking the persistence factors throughout a student's college experience would provide insight into changes students may face and the persistence factors that may change from year to year. Including multiple universities would help provide further insight, like this study, into the different persistent factors present at different universities. Additional research with demographics is important to address issues students face with engineering identity. Socioeconomic status is another factor that could be analyzed to help meet the needs of those students.

Qualitative research would be valuable to complement quantitative findings as it would allow for a more in-depth understanding of students' experiences and perceptions. Incorporating qualitative with quantitative in a mixed study with multiple universities would provide valuable insight into the why of engineering persistence. The current quantitative study helps identify persistence factors but a mixed method study would help provide the why.

Investigating transition points within engineering education, such as freshman to sophomore year or between classwork and co-ops/internships could provide insight into critical points in a student's experience. Having this information would provide universities with targeted retention strategies during these transitions. Instead of offering general retention strategies, this information could target difficult times for students and provide the support needed.

Pre-college factors emphasize the importance of academic preparedness through rigorous courses, high GPAs, and ACT scores. There are mixed results on the effectiveness of a pre-engineering curriculum. Additional research is warranted to investigate different types of pre-engineering curriculum and their effectiveness. Research in this area would provide valuable information for high schools in determining course offerings and how to properly support students who plan to major in engineering.

College faculty perspectives, curriculum, the attitude of faculty toward student success, and teaching methods research would be valuable to help with the "chilly climate" hypothesis. While research points to the influence of institutional and classroom climate on engineering persistence, a look into how new curricula and teaching methods are important. Some universities have transitioned from a more theoretical approach to a more hands-on approach and provided professional development for professors. Research in this area would give engineering education insight into what is needed for engineers to be successful once they graduate.

Long-term outcomes research that looks at persistence factors that include graduation rates and post-graduation success would help in understanding how persistence influences future outcomes. With research focused on pre-college and college factors to help students persist it is important to look at how all the strategies to help students graduate influence their success post-graduation. Research on job placement and remaining in engineering as a career would provide valuable insight into persistence factors that make a difference in career success.

Summary of Study

Engineering persistence research is important in addressing the decrease in enrollment of students in engineering schools, decreased graduation rates, and the need for more engineers. This study addressing the research questions regarding engineering persistence comparing two university types, gender and race/ethnicity helps address some of these factors. Findings suggest that certain persistence factors are influenced based on the type of university, gender, and race/ethnicity. This study supports existing research in engineering persistence while also offering additional indicators related to pre-college, college, and retention factors.

Pre-college factors identified include a student's motivation to major in engineering, proficiency in math or science, passion for problem-solving, and career prospects such as obtaining a well-paying job. High school academic preparedness, particularly GPA, ACT scores, and multiple AP, honors, or advanced classes are predictors of engineering school persistence. While pre-engineering persistence varies, this study suggests future additional research due to the low involvement of students in pre-engineering programs.

College and retention factors include students' confidence in degree completion, academic support strategies, involvement and engagement in social activities, co-ops and internships, and the influence of institutional and classroom climate. Social and personal factors such as peer and parental support, self-efficacy, and engineering identity are significant in student persistence. These findings support previous research on social and academic integration contributing to student persistence.

University comparison of the two institutions identified significant factors of high school GPA, initial confidence, and institutional climate at the regional university. Scholarships, high school preparation, specifically ACT scores, and social aspects were crucial at the R2 research university. Gender comparisons revealed variations with females emphasizing involvement and satisfactory grades. Race/ethnicity had differences among racial and ethnic groups in factors of program preferences, activity involvement, and engineering identity. These findings indicate the need for higher education to provide support strategies based on their characteristics and the needs of their engineering students.

References

Adelman, C. (1999). *Answers in the toolbox: Academic intensity, attendance patterns, and bachelor's degree attainment*. Washington, DC: U.S. Department of Education.

Adelman, C. (2006). *The toolbox revisited: Paths to degree completion from high school through college.* Washington, DC: U.S. Department of Education.

Astin, A.W. (1999). Student involvement: A developmental theory for higher education. *Journal of College Student Development, 40*(5), 518-529.

AWE. (n.d.). Aweonline.org. Retrieved September 24, 2023, from http://aweonline.org/persist.html

Basic classification. CARNEGIE CLASSIFICATION OF INSTITUTIONS OF HIGHER EDUCATION. (2023, March 30). https://carnegieclassifications.acenet.edu/carnegie-classification/classification-methodology/basic-classification/

Bean, J.P. (1988). Leaving college: Rethinking the causes and cures of student attrition by Vincent Tinto. *The Journal of Higher Education, 59*(6), 708-711.

Bean, J., & Eaton, S.B. (2001). The psychology underlying successful retention practices. *Journal of College Student Retention: Research, Theory and Practice, 3*(1), 73-89.

Bernold, L.E., Spurlin, J.E., & Anson, C.M. (2007). Understanding our students: A longitudinal study of success and failure in engineering with implications for increased retention. *Journal of Engineering Education, 96*(3), 263-274.

Braunstein, A., McGrath, M., & Pescatrice, D. (2001). Measuring the impact of financial factors on college persistence. *Journal of College Student Retention, 2*(3), 191-203.

Burtner, J. (2004). Critical-to-quality factors associated with engineering student persistence: The influence of freshman attitudes. *34th Annual Frontiers in Education.*

Burtner, J. (2005). The use of discriminant analysis to investigate the influence of non-cognitive factors on engineering school persistence. *Journal of Engineering Education, 94*(3), 335-338.

Cabrera, A.F., Castaneda, M.B., Nora, A., & Hengstler, D. (1992). The convergence between two theories of college persistence. *The Journal of Higher Education, 63*(2), 143-164.

Cancado, L., Reisel, J.R., & Walker, C.M. (2018). Impacts of a summer bridge program in engineering on student retention and graduation. *Journal of STEM Education, 19*(2), 26-31.

Cech, E., Rubineau, B., Silbey, S., & Seron, C. (2011). Professional role confidence and gendered persistence in engineering. *American Sociological Review, 75*(5), 641-667.

Charboneau, T. (2020, April 8). *What prevents many EE students from "making it" to professional careers? - news*. All About Circuits. https://www.allaboutcircuits.com/news/what-prevents-many-ee-students-from-making-it-to-professional-careers/

Cole, B., High, K., & Weinland, K. (2013). High school pre-engineering programs: Do they contribute to college retention? *American Journal of Engineering Education, 4*(1), 85-98.

Conley, D.T. (2007). *Redefining college readiness*. Washington, DC: Educational Policy Improvement Center.

Daempfle, P. A. (2003). An analysis of the high attrition rates among first-year college science, math, and engineering majors. *Journal of College Student Retention: Research, Theory & Practice, 5*(1), 37-52.

Davis, C. E., Yeary, M. B., & Sluss, J. J. (2011). Reversing the trend of engineering enrollment declines with innovative outreach, recruiting, and retention programs. *IEEE Transactions on Education*, *55*(2), 157-163.

Desai, N, & Stefanek, G. (2017). A literature review of the different approaches that have been implemented to increase retention in engineering programs across the United States. *American Society for Engineering Education, 1*, 1-8.

Desai, N. H., & Stefanek, G. (2017, June). An introductory overview of strategies used to reduce attrition in engineering programs. In *2017 ASEE Annual Conference & Exposition*.

Dowd, C.A., & Coury, T. (2006). The effect of loans on the persistence and attainment of community college students. *Research in Higher Education, 47*(1), 33-62.

Elkins, S.A., Braxton, J.M., & James, G.W. (2000). Tinto's separation stage and its influence on first-semester college student persistence. *Research in Higher Education, 41*(2), 251-268.

Eris, O., Chachra, D., Chen, H.L., Sheppard, S., Ludlow, L., Rosca, C., Bailey, T., & Toye, G. (2010). Outcomes of a longitudinal administration of the persistence in engineering survey. *Journal of Engineering Education, 99*(4), 371-395.

Fantz, T.D., Siller, T.J., & DeMiranda, M.A. (2011). Pre-collegiate factors influencing the self-efficacy of engineering students. *Journal of Engineering Education, 100*(3), 604-623.

French, B.F., Immekus, J.C., & Oaks, W.C. (2005). An examination of indicators of engineering students' success and persistence. *Journal of Engineering Education, 94*(4), 419-425.

Garcia-Ros, R., Perez-Gonzalez, F., Cavas-Martinez, F., & Tomas, J.M. (2018). Effects of pre-college variables and first-year engineering students' experiences on academic achievement and retention: A structural model. *International Journal of Technology and Design Education, 29*, 915-928.

Geisinger, B.N., & Raj Raman, D. (2013). Why they leave: Understanding student attrition from engineering majors. *International Journal of Engineering Education*, *29*(4), 914-925.

Godfrey, E., Aubrey, T., & King, R. (2010). Who leaves and who stays? Retention and attrition in engineering education. *Engineering Education, 5*(2), 25-40.

Graffigna, A.M., Hidalgo, L., Jofre, A., del Carmen Berenguer, M., Moyano, A., & Esteybar, I. (2014). Tutorial practice as a strategy of retention at the school of engineering. *Social and Behavioral Sciences, 116*, 2489-2493.

Hall, C.W., Kauffmann, P.J., Wuensch, K.L., Swart, W.E., DeUrquidi, K.A., Hayden Griffin, O., & Duncan, C.S. (2015). Aptitude and personality traits in retention of engineering students. *Journal of Engineering Education, 104*(2), 167-188.

Hirsch, L. S., Kimmel, H., Rockland, R., & Bloom, J. (2005, October). Implementing pre-engineering curricula in high school science and mathematics. In *Proceedings Frontiers in Education 35th Annual Conference* (pp. S2F-21). IEEE.

Hirsch, L. S., Kimmel, H., Rockland, R., & Bloom, J. (2006, October). Using pre-engineering curricula in high school science and mathematics: A follow-up study. In *Proceedings. Frontiers in Education. 36th Annual Conference* (pp. 1-6). IEEE.

Honken, N. B., & Ralston, P. (2013). Freshman engineering retention: A holistic look. *Journal of STEM Education: Innovations and Research, 14*(2).

Hsiao, K.P. (1992). First-generation college students. *ERIC Digest*.

Hu, K., Godfrey, K., Ren, Q., Wang, S., Yang, X., & Li, Q. (2022). The impact of the COVID-19 pandemic on college students in USA: Two years later. *Psychiatry Research, 315, 114685.*

Hu, S. (2011). Reconsidering the relationship between student engagement and persistence in college. *Innovation in Higher Education, 36,* 97-106.

Hughes, B. E., Schell, W. J., Annand, E., Beigel, R., Kwapisz, M. B., & Tallman, B. (2019, June). Do I Think I'm an Engineer? Understanding the Impact of Engineering Identity on Retention. In *American Society for Engineering Education*.

Jackson, L.A., Gardner, P.D., & Sullivan, L.A. (1993). Engineering persistence: Past, present, and future factors and gender differences. *Higher Education*, *26*(2), 227-246.

Krause, S. J., Middleton, J. A., Judson, E., Ernzen, J., Beeley, K. R., & Chen, Y. C. (2015, June). Factors impacting retention and success of undergraduate engineering students. In *2015 ASEE Annual Conference & Exposition* (pp. 26-758).

Kuley, E. A., Maw, S., & Fonstad, T. (2015). Engineering student retention and attrition literature review. *Proceedings of the Canadian Engineering Education Association (CEEA)*.

Leppel, K. (2001). The impact of major on college persistence among freshman. *Higher Education*, *41*, 327-342.

Lin, P. P. (2017). How to improve engineering recruitment and retention. *American Society for Engineering Education. Cleveland State University*.

Marra, R. M., Rodgers, K. A., Shen, D., & Bogue, B. (2012). Leaving engineering: A multi-year single institution study. *Journal of Engineering Education*, *101*(1), 6-27.

Mau, W.C. (2003). Factors that influence persistence in science and engineering career aspirations. *The Career Development Quarterly, 51*(3), 234-243.

McCharen, B., & High, K. (2010). Career and technical programs of study and early indicators of retention in the College of Engineering. *Association of Career and Technical Education Research, Ames*.

Meyer, M., & Marx, S. (2014). Engineering dropouts: A qualitative examination of why undergraduates leave engineering. *Journal of Engineering Education, 104*(4), 525-548.

Miller, K.A., Sonnert, G., & Sadler, P.M. (2020). The influence of student enrollment in pre-college engineering courses on their interest in engineering careers. *Journal of Pre-College Engineering Education Research, 10*(1), 90-102.

Moses, L., Hall, C., Wuenchsch, K., De Urquidi, K., Kauffmann, P., Swart, W., Duncan, S., & Dixon, G. (2011). Are math readiness and personality predictive of first-year retention in engineering? *The Journal of Psychology, 145*(3), 229-245.

Niu, S.X., & Tienda, M. (2013). High school economic composition and college persistence. *Research for Higher Education, 54*, 30-62.

Ohland, M.W., Sheppard, S.D., Lichtenstein, G., Eris, O., Chachra, D., & Layton, R.A. (2008). Persistence, engagement, and migration in engineering programs. *Journal of Engineering Education, 97*(3), 259-278.

Ravid, R. (2020). *Practical statistics for educators*. Rowman & Littlefield.

Reason, R.D. (2009). Student variables that predict retention: Recent research and new developments. *NASPA Journal, 46*(3), 482-501.

Ryan, J.F. (2004). The relationship between institutional expenditures and degree attainment at baccalaureate colleges. *Research in Higher Education, 45*(2), 97-114.

Santiago, L. Y., & Hensel, R. A. (2012, June). Engineering attrition and university retention. In *2012 ASEE Annual Conference & Exposition* (pp. 25-538).

Santiago, L. (2013, June). Retention in a first-year program: Factors influencing student interest in engineering. In *2013 ASEE Annual Conference & Exposition* (pp. 23-1045).

Seymour, E. & Hewitt, N. (1994). Talking about leaving: Factors contributing to high attrition rates among science, mathematics, and engineering undergraduate majors. *Journal of Chemical Education, 71*(12).

Shuman, L. J., Delaney, C., Wolfe, H., & Scalise, A. (1999, June). Engineering attrition: Student characteristics and educational initiatives. In *1999 Annual Conference* (pp. 4-229).

Smart, J.C. (2011). *Higher education: Handbook of theory and research volume 26*. Springer Netherlands.

Sternberg, R. J. (2013). Research to improve retention. *Inside Higher Ed*.

Stewart, S., Lim, D.H., & Kim, J. (2015). Factors influencing college persistence for first-time students. *Journal of Developmental Education, 38*(3), 12-16.

Suhre, J.M., Jansen, E., & Harskamp, E.G. (2007). Impact of degree program satisfaction on the persistence of college students. *Higher Education, 54*, 207-226.

Suresh, R. (2007). The relationship between barrier courses and persistence in engineering. *Journal of College Student Retention, 8*(2), 215-239.

Therriault, S.B., & Krivoshey, A. (2014). College persistence indicators research review. American Institutes for Research.

Tinto, V. (1975). Dropout from higher education: A theoretical synthesis of recent research. *Review of Educational Research, 45*, 89-125.

Tinto, V. (1993). Leaving college: Rethinking the causes and cures of student attrition. University of Chicago Press.

Titus, M.A. (2004). An examination of the influence of institutional context on student persistence at 4-year colleges and universities: A multilevel approach. *Research in Higher Education*, *45*(7), 673-699.

Tran, N.A., & Nathan, M.J. (2010). The effects of pre-engineering studies on mathematics and science achievement for high school students. *International Journal of Engaging Education*, *26*(5), 1049-1060.

Tyson, W. (2011). Modeling engineering degree attainment using high school and college physics and calculus course taking and achievement. *Journal of Engineering Education, 100*(4), 760-777.

Utley, J., Ivey, T., & Weaver, J. (2019). Effect of project lead the way participation on retention in engineering degree programs. *Journal of Pre-College Engineering Education Research, 9*(2), 40-50.

Veenstra, C.P., Dey, E.L., & Herrin, G.D. (2008). Is modeling of freshman engineering success different from modeling of non-engineering success? *Journal of Engineering Education, 97*(4), 467- 479.

Veenstra, C. P. (2009). A strategy for improving freshman college retention. *Journal for Quality and Participation*, *31*(4), 19-23.

Veenstra, C. P., Dey, E. L., & Herrin, G. D. (2009). A model for freshman engineering retention. *Advances in Engineering Education*, *1*(3), n3.

Walsh, K.J., & Kurpius, E.R. (2015). Parental, residential, and self-belief factors influencing academic persistence decisions of college freshmen. *Journal of College Student Retention: Research, Theory & Practice, 18*(1), 49-67.

Wang, X., Dai, M., & Mathis, R. (2022). The influences of student- and school-level factors on engineering undergraduate student success outcomes: A multi-level multi-school study. *International Journal of STEM Education*, *9*(1), 23-46.

Yockey, R. D. (2018). *SPSS Demystified.* Routledge.

Appendix A

Murray State University IRB Approval Letter

MURRAY STATE UNIVERSITY

Institutional Review Board
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Murray, KY 42071-3318
(270)809-2916
Msu.irb@murraystate.edu

Date: 01/09/2023

Principal Investigator: Stephen Drawbaugh

Faculty Sponsor: Jay Parrent

IRB Approver: Justin Brogan

IRB Reference Number: 24-119

The IRB has completed its review of Exempt protocol Factors influencing Engineering Student Persistence: A Two institution Study After review and consideration, the IRB has determined that the research as described in the protocol form, will be conducted in compliance with Murray State University Guidelines for the Protection of human participants.

The forms and materials approved for use in this research study are attached to the email containing this letter. These are the forms and materials that must be presented to the subjects. Use of any process or forms other than those approved by the IRB will be considered misconduct in research as stated in the MSU IRB procedures and Guidelines section 20.3.

Your stated data collection period is from 01/09/2024-01/09/2025

If data collection extends beyond this period, please submit a continuation to an approved protocol form detailing the new data collection period and the reason for the change.

This Exempt approval is valid until 01/09/2025.

If data collection and analysis extends beyond this date, the research project must be reviewed as a continuation project by the IRB prior to the end of the approval period, 01/09/2025. You must reapply for IRB approval by submitting a Project Update and Closure form (available at murraystate.edu/IRB). You must allow ample time for IRB processing and decision before your expiration date, or your research must stop until IRB approval is received. If the research project is completed by the end of the approval period, a Project Update and Closure form must be submitted for the IRB review so your protocol may be closed. It is your responsibility to submit the appropriate paperwork promptly.

This protocol is approved. You may begin data collection now.

Appendix B

University of Louisville Approval for Student Participation

UNIVERSITY OF LOUISVILLE

Human Subjects Protection Program Office
300 E. Market St. Suite 300
Louisville, KY 40202
Office: 502.852.5188 Fax: 502.852.2164

January 19, 2024
Study Title: Factors influencing Engineering Student Persistence: A Two institution Study

The Human Subjects Protection Program Office (HSPPO) has received the materials submitted concerning the above noted project. We understand that University of Louisville students will be recruited for participation in a survey research study approved by the Murray State IRB.

The submission does not meet the definition of engagement in research as outlined in the October, 2008 memorandum from the Office of Human Research Protections as noted in section B, which states the following as an examples of institutional involvement that would make an institution not engaged in human subjects research:

- Institutions (e.g., schools, nursing homes, businesses) that permit use of their facilities for intervention or interaction with subjects by investigators from another institution.

Murray State IRB is the IRB of record for this research project.
The University of Louisville is not engaged in the research.

University of Louisville schools/units/departments can determine if they are interested in participating in this research. You are responsible for following the procedures and requirements of the departments you contact at the University of Louisville.

If the University of Louisville role on this project changes, or you have any additional questions, please contact our office at hsppofc@louisville.edu.

Christy LaDuke

Christy LaDuke, MA, CIP, CCRP
Director, HSPPO

Appendix C

Email to Participants

Subject: Invitation to Participate in Engineering Persistence Survey

Dear Engineering Students,

I hope this email finds you well. My name is Stephen Drawbaugh, and I am a doctoral student in the Department of Education Studies, Leadership, and Counseling at Murray State University. I am researching factors influencing persistence in engineering education and inviting you to participate in my survey.

Survey Details:

- Study Title: Factors Influencing Engineering Student Persistence: A Two-Institution Study
- Survey Title: Persistence in Engineering Survey
- Purpose: To understand the factors that contribute to the persistence of students in engineering programs.
- Duration: 43 questions that will take approximately 15-20 minutes
- Voluntary Participation: Participation in this survey is entirely voluntary, and you are free to withdraw at any time without any consequences.
- Confidentiality: All responses will be kept confidential, and your identity will not be disclosed in any publications or presentations resulting from this research.

I have attached the Informed Consent Form to this email, which provides detailed information about the survey, its purpose, and your rights as a participant. Please take the time to read this document carefully before deciding whether or not you would like to participate.

Survey Link: Persistence in Engineering Survey

Important Points:

- Your participation is crucial to the success of this research, and your honest responses will contribute valuable insights to the field of engineering education.
- Completing the survey implies that you have read and understood the attached Informed Consent Form and voluntarily agree to participate.
- Participants will receive no compensation for taking part in this survey.

If you have any questions or concerns, please contact me at sdrawbaugh@murraystate.edu. I appreciate your time and consideration and look forward to you participating in this important research.

Thank you,

Stephen Drawbaugh

EdD Candidate in the Department of Education Studies, Leadership, and Counseling at Murray State University

Appendix D

Engineering Persistence Factors Survey

Part 1: Informed Consent

1. Informed Consent Acknowledgement

Thank you for participating in our survey. Before you proceed, please ensure that you have read the attached consent form sent to you via email. By continuing with this survey, you are confirming that:

1. You have read and understood the information provided in the attached consent form sent in email.
2. You voluntarily agree to participate in this study based on the terms outlined in the consent form.
3. You are aware that you have the right to withdraw from the study at any time without penalty.

If you have any questions or concerns regarding the study or the consent form, please contact Stephen Drawbaugh at sdrawbaugh@murraystate.edu. By clicking below and continuing with the survey, you are indicating your consent to participate in this study.

□ I agree to participate in this engineering persistence survey

Part 2: Engineering Persistence Factors

2. Please indicate your race-ethnicity(ies). Select all that apply.

Check all that apply.

□ American Indian or Alaska Native
□ Asian or Asian American
□ Black or African American
□ Hispanic, Latino, Latina, or Latinx
□ Middle Eastern or Northern African
□ Native Hawaiian or Other Pacific Islander
□ White
□ I prefer not to answer this question

3. Please indicate your gender.

□ Male
□ Female
□ I prefer not to answer this question

4. School Year

□ Sophomore
□ Junior
□ Senior

5. Engineering Major

Mark only one.

□ Aerospace Engineering
□ Bioengineering
□ Chemical Engineering
□ Civil Engineering
□ Computer Engineering
□ Computer Science
□ Cybersecurity
□ Data Science
□ Design Engineering Technology
□ Electrical Engineering
□ Electromechanical Engineering
□ Engineering Fundamentals
□ Engineering Management
□ Environmental Engineering
□ Healthcare Systems Engineering
□ Industrial Engineering
□ Manufacturing Engineering
□ Materials and Energy Science
□ Mechanical Engineering
□ Structural Engineering
□ Transportation Engineering

6. Where were you immediately before your first semester/term at this institution?

Mark only one

□ High School
□ 2-year College
□ 4-year College
□ Working Full Time
□ Military

7. What was your cumulative GPA at the end of the most recent academic semester/term?

Mark only one

□ Below 1.5
□ 1.50 – 1.99
□ 2.00 – 2.49
□ 2.50 – 2.99
□ 3.00 – 3.49
□ 3.50 – 4.00

Part 3: Student Persisting in Engineering Survey – High School Questions

Complete the following questions related to your perception of reasons you have persisted in engineering based on your high school experience.

8. Why did you initially decide to major in engineering? (Check all that apply)

□ Attracted by the challenge of a difficult curriculum
□ Good at math or science
□ High School advisor or teacher recommended
□ Like to solve problems
□ Like the design work that engineers do
□ Participated in an engineering camp or workshop that influenced me
□ Parents, other relatives, or friends is an engineer
□ Parents, siblings, or other relatives recommended it
□ Received or anticipated the possibility of a good college scholarship
□ Wanted to be able to get a well-paying job after I graduate
□ Wanted to use engineering solutions to address social problems
□ Took engineering classes in high school and enjoyed them

9. Check all the courses below that indicate if you completed any of these honors or advanced courses during high school.

□ Algebra
□ Biology
□ Computer Science
□ Pre-calculus
□ Calculus
□ Chemistry
□ English
□ Geometry
□ History
□ Physics
□ Trigonometry
□ Engineering

10. If you participated in engineering during high school which type of program were you involved in?

Check all that apply

□ PLTW Engineering
□ Other Engineering Classes (NOT PLTW)
□ Club (TSA, Skills, etc.)
□ Did not take engineering courses in high school

11. If you participated in engineering in high school how many years were you involved (either clubs or taking classes)?

□ 1 year
□ 2 years
□ 3 years
□ 4 years
□ Did not participate in engineering during high school

12. Do you feel your high school coursework adequately prepared you to be successful in an engineering curriculum?

□ Yes
□ No

13. What was your unweighted cumulative high school GPA at graduation?

□ Below 1.5
□ 1.50 – 1.99
□ 2.00 – 2.49
□ 2.50 – 2.99
□ 3.00 – 3.49
□ 3.50 – 4.00

14. What was your ACT score?

□ 15 – 20
□ 21 – 25
□ 26 – 30
□ 31 – 36

Part 4: Student Persisting in Engineering Survey – College Questions

Complete the following questions related to your perception of reasons you have persisted in engineering.

15. When you **began** your engineering degree, how confident were you that you would complete it?

- □ Not very confident; I was already unsure of my plan to study engineering
- □ I felt there was about a 50% chance that I would complete a degree in engineering
- □ I was fairly confident that I would complete a degree in engineering
- □ I was very confident that I would complete a degree in engineering

16. At the present time, how confident are you that you will complete an engineering degree at this institution?

- □ Not very confident; it is highly unlikely I will complete an engineering degree
- □ There is about a 50% chance that I will complete a degree in engineering
- □ I am fairly confident that I will complete a degree in engineering
- □ I am very confident that I will complete a degree in engineering

Part 5: Engineering Activities Involvement

The following is a list of engineering activities (co-curricular and academic). For each activity indicate your level of involvement during the most recent academic year (e.g. August to May).

1- Not Involved
2 - 1-2 times/year
3 - 3-5 times/year
4 - more than 5 times/year

17. An engineering society

- □ 1- Not Involved
- □ 2 - 1-2 times/year
- □ 3 - 3-5 times/year
- □ 4 - more than 5 times/year

18. An engineering fraternity or sorority

- □ 1- Not Involved
- □ 2 - 1-2 times/year
- □ 3 - 3-5 times/year
- □ 4 - more than 5 times/year

19. A professional or student group for women or minority engineers

- □ 1- Not Involved
- □ 2 - 1-2 times/year
- □ 3 - 3-5 times/year
- □ 4 - more than 5 times/year

20. Minority/Multicultural engineering program-sponsored activities

□ 1- Not Involved
□ 2 - 1-2 times/year
□ 3 - 3-5 times/year
□ 4 - more than 5 times/year

21. Women in engineering program or women in science and engineering-sponsored activities

□ 1- Not Involved
□ 2 - 1-2 times/year
□ 3 - 3-5 times/year
□ 4 - more than 5 times/year

22. Activities (social or academic) sponsored by your department or major

□ 1- Not Involved
□ 2 - 1-2 times/year
□ 3 - 3-5 times/year
□ 4 - more than 5 times/year

23. Design Competition Teams

□ 1- Not Involved
□ 2 - 1-2 times/year
□ 3 - 3-5 times/year
□ 4 - more than 5 times/year

24. Undergraduate research experiences

□ 1- Not Involved
□ 2 - 1-2 times/year
□ 3 - 3-5 times/year
□ 4 - more than 5 times/year

25. Co-op or professional internship position

□ 1- Not Involved
□ 2 - 1-2 times/year
□ 3 - 3-5 times/year
□ 4 - more than 5 times/year

26. The following is a list of academic and/or academic preparation activities. Check all the activities in which you engaged during the last academic year (e.g. August to May)

- □ Attended engineering orientation prior to beginning classes
- □ Attended summer program designed to prepare me to begin the engineering curriculum
- □ Attended review sessions before exams
- □ Called or emailed parents or others about difficulties I was experiencing in classes or school
- □ Got advice from a mentor in a formal mentoring program
- □ Lived in honors or other non-engineering special interest dorm
- □ Participated in engineering-focused living arrangements (dorm, engineering fraternity)
- □ Participated in formal or informal study groups
- □ Received tutoring for courses where I was experiencing difficulty
- □ Scheduled an appointment with a professor and/or graduate assistant outside of his or her office hours
- □ Sought help from other engineering students when I experienced difficulties in classes
- □ Visited a professor and/or graduate assistant in her or his office hours
- □ Visited or emailed an advisor or advising center
- □ Visited the Career Center or Co-op Office to seek assistance with job search (permanent, internship, or co-op)

27. Do you currently participate in any college/university athletic activities (intramural or official)?

- □ Yes
- □ No

28. Do you work during the academic year?

- □ Yes
- □ No

29. When you have an academic problem in engineering, what do you do? (Rank your top 3 choices)

- □ Do something social or something that relaxes me (exercise, read, etc.)
- □ Form or join a student study group
- □ I never feel this way
- □ Nothing
- □ Seek academic help at a tutoring center
- □ Spend more time studying
- □ Talk to a faculty member
- □ Talk to a mentor
- □ Talk to the engineering adviser and/or advising staff
- □ Talk to other students and/or friends
- □ Talk to my parents or siblings

30. How supportive are your parents/guardians in your decision to study engineering?

□ Very supportive
□ Somewhat supportive
□ Did not have a preference
□ Somewhat against
□ Firmly against
□ Did not discuss the decision

Part 5: Persistence Factors

The following are factors associated with you persisting in your engineering education. For each factor, choose a column ranging from No Influence to Significant Influence to indicate the degree to which that factor influences your persistence in engineering (no influence, small influence, moderate influence, significant influence).

31. Sufficient opportunities for financial aid or scholarships

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

32. Engineering faculty/departmental personnel show an interest in me

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

33. Reasonable workload of the engineering classes

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

34. Friendly climate in engineering classes

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

35. Satisfactory performance on my grades in engineering

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

36. Faculty help me understand what practicing engineers do

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

37. Good teaching by engineering faculty, instructors, or graduate assistants

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

38. Effective academic advising by engineering faculty or advisors

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

39. Ability to find satisfactory co-ops and/or internships

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

40. My personal abilities/talents “fit” the requirements of engineering

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

41. Confident of succeeding in engineering future classes

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

42. Positive interactions with other engineering students

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence

43. Positive experiences in design teams or other collaborative learning experiences in engineering

□ 1 – no influence
□ 2 – small influence
□ 3 – moderate influence
□ 4 – significant influence