EXPLORING THE CHARACTERISTICS

OF STUDENTS FROM A PRE-ENGINEERING PROGRAM

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Abstract:

The number of students graduating with engineering degrees has been decreasing leading to many STEM career vacancies. One possible solution is an earlier exposure to engineering and preparation for the rigorous undergraduate coursework could help increase the number of prepared and qualified individuals to fill these STEM career vacancies. This mixed methods study explored the characteristics of 141 students who completed a high school pre-engineering program the previous school year. Using data from surveys, interviews, and archival data, the findings from this research reveal why students attend a pre-engineering program, what helped them succeed, and an analysis of their personal, cognitive (GPAs), and non-cognitive characteristics (mathematics self-efficacy, grit, and mindset). The results revealed that engineering interests, rigorous coursework, a contextual learning environment, and word-of-mouth attract students to the program. Students contributed success in the program to the overview of engineering the program provided and the knowledgeable and supportive instructors. The analysis of characteristics found that the student population in the program is predominately white males, the program is a smaller and different ethnically diverse school environment than the students' local high school, and mindset scores differ depending on the level of completion. This study leaves behind implications for the administration and instructors of pre-engineering programs to review program marketing, admission's requirements, and the pedagogy of the courses.

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CHAPTER I

INTRODUCTION

Careers in the STEM fields affect everyday lives – from health care to national security (Association of Career and Technical Education [ACTE], 2009). In the U.S., the demand for STEM professionals is growing faster than ever. For example, the Association of Career and Technical Education (ACTE) (2009) reported that more than one-quarter of people with science and engineering degrees were over the age of 50. This means that at least 25% of all STEM professionals with college degrees are expected to retire in the next 10 years (ACTE, 2009). Another report indicated that over half of the STEM workforce will retire in 20-30 years (Marshall, Coffey, Saalfeld, & Colwell, 2004) and more than 13,000 STEM-skilled workers at the Department of Defense (DoD) are expected to retire in the next 10 years. Over half of the aerospace industry were reported to be over the age of 50 and 27% of those engineers are already eligible for retirement (Aerospace Industries Association [AIA], 2008). A survey of chief executive officers showed that they will need to hire nearly one million STEM-literate employees and over one-half million employees with advanced STEM knowledge (DeWitt, 2015). These statistics indicate there is a plethora of STEM jobs available and even more will open in the very near future.

One critical component of our nation's economy is a science, technology, engineering, and mathematics (STEM) literate society. Since World War II, the United States (U.S.) has led the world in technological advances, but our competition is quickly catching up (Denney, 2011). When the Soviet Union launched Sputnik in 1957, STEM interest in the U.S. skyrocketed. The Sputnik-spurred generation is retiring and upcoming generations need to fill their shoes. More recently, terrorist attack have been on the rise worldwide (Institute for the Analysis of Global Security, 2004). Now, more than ever, the US needs innovative and cutting edge technological advances to protect our nation. In order for a nation to stay competitive with other nations, a skilled workforce in STEM fields must be produced (ACTE, 2009; Denney, 2011).

While STEM job opportunities are increasing, the number of qualified graduates is decreasing (Task Force on the Future of American Innovation, 2005). According to ACTE (2009), from 1985 to 2005, the number of engineering degrees earned decreased by more than 10,000. Freeman (2006) found the percent of STEM degrees decreased from 30% to 14% between 1970 and 2000. In 2002, only 17% of undergraduate degrees awarded in the U.S. were in STEM fields, a very low number for such a large global competitor. The United States' 17% is a stark contrast to China's 53% (National Science Foundation [NSF], 2006). In 2016, the U.S. issued 8,400 H1B Visas for mechanical engineers, the most of any engineering occupation ("Top H1B Visa Sponsor by Occupation", n.d.). In order to fill the jobs needed in the US economy, STEM education must become a priority (ACTE, 2009).

Some research suggests that students are losing interest in pursuing STEM careers. In one survey of more than 270,000 college freshmen, less than eight percent intended on majoring in engineering, the lowest percent since the 1970 (AIA, 2008). Another study reported that in 2009, approximately 30% of incoming freshmen declared a STEM major (HERI, 2010). A 2003 survey by the National Center for Educational Statistics (NCES) found that only 14% of all undergraduates had declared a STEM major in the 1995-1996 school year, and of those students, 55% either changed their major to a non-STEM field or left their institution by 2001 (Chen, 2009). Additionally, students who pursue STEM majors are actually more likely to change their major when compared to business, education, and humanities majors (King, 2015).

To keep up with the competition, the U.S. needs to fill the jobs that are vacated by retirees and the jobs that are being created with technological advances. STEM awareness needs to increase, and more than that, the perseverance of those interested needs to be supported. STEM jobs are on the rise and it is up to the education systems to help educate and peak the curiosity of the forming minds of our future leaders. Thus, the purpose of this study is to explore one possible strategy for increasing students' interest in STEM – a high school pre-engineering program.

Theoretical Framework

Social cognitive theory suggests that behavior is determined by a triadic reciprocal system. Personal factors, behavior, and environmental factors reciprocally influence each other (Figure 1). These influences can act in sequence with as many three factors or as few as one factor. The three factors individually vary in strength at any one time. This system evolves over time and changes according to maturation and life events (Bandura, 1989).

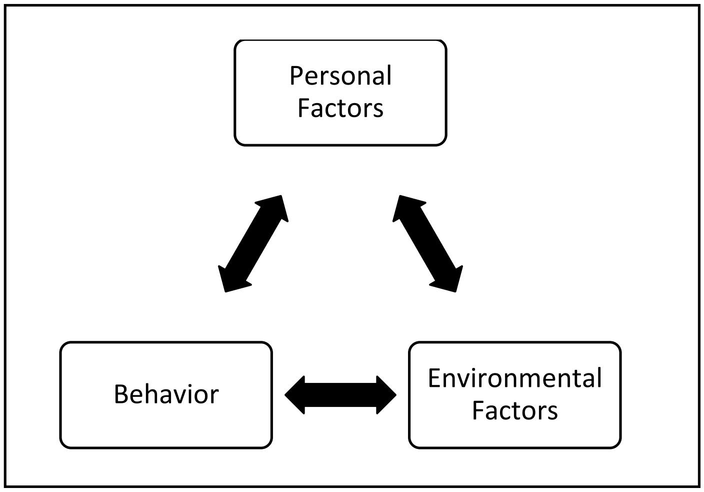

Figure 1. Social Cognitive Theory.

A person's biological make-up can enhance or restrain capabilities behaviorally and shape the environment in which the person is surrounded. Expectations, beliefs, self-perceptions, and goals are also personal factors that play a role in how a person reacts emotionally or behaviorally. In the same way, these expectations, beliefs, self-perceptions, and goals are influenced by the social interactions within the environment (Bandura, 1989). In this study, social cognitive theory will be used as a framework for how students make career decisions and whether they persevered in a program of study.

The influences of the environment surrounding a person can affect behavior consciously or unconsciously. For example, a college student is not going to gain anything from a lecture unless the student chooses to attend the lecture. Therefore, unless they decide to put themselves into that environment, it will not influence them. Conversely, some environments are fixed and have the potential to influence an individual (e.g. poverty). A child growing up in poverty will be influenced in some sort by the surrounding poverty-induced conditions without choice. "People are both products and producers of their environment" (Bandura, 1989, p. 4).

This triadic reciprocal relationship of influences is not a fixed system. Personal, behavioral, and environmental factors influence the life paths and will vary in strength throughout life's events. Many of the life direction factors are created during the years of education and the familial influences throughout the school ages (Bandura, 1989).

As it relates to this study, the knowledge students gain in the classroom, and the decisions students make about their education and careers, are influenced by their behavior, personal, and environmental factors. In the classroom, when the teacher proposes an academic question to a student, the answer is determined by that students' self-perception of their ability to answer (personal factor) and the encouragement and support from the classroom of peers and teacher (environmental factor). Academically, behaviors can be thought of as self-regulated by personal factors. As students assess their own practice, they either decide to either continue or discontinue a specific behavior due to their level of success or lack thereof. Their own self-regulating (personal) factors guide their specific behavior. Learning strategies of students also relates to Bandura's social cognitive theory. As students learn what helps and what hinders their learning, they adapt and purposefully choose specific environments and behavior to ensure continued success (Zimmerman, 1989).

Problem Statement and Rationale

With STEM job opportunities increasing, the U.S. will need well-educated citizens to fill these positions. In order to fill these STEM jobs, the pipeline leading to STEM majors and the support these students need to be successful has to grow. Increasing the pipeline means getting students involved, informed, and interested about the STEM field and the related careers earlier in school.

In an effort to increase students' interest in STEM careers, thousands of STEM-related programs have been launched in the last 10 years, especially within the Career and Technology Education (CTE) system. CTE STEM programs allow students to gain a deeper understanding of career pathways that interest them and give students an opportunity to engage hands-on, career relevant materials that would otherwise not be included in the traditional academic education. The engaging aspect of CTE's STEM programs gives meaning and context to important concepts in science and mathematics (ACTE, 2009). A study conducted at Massachusetts Institute of Technology (2009) revealed that more students are showing an interest in STEM fields, but are hesitant to pursue those careers because they do not know anyone that works in that field nor do they understand what STEM careers entail.

To help fill the present and expected STEM career vacancies, this study will look into one of the possible solutions to expanding the STEM pipeline – a high school pre-engineering program at a CTE school. Specifically, this study will analyze the characteristics of students who have completed one of three pathways in the pre-engineering program at Tulsa Technology Center (TTC) – foundations of engineering, pre-engineering, and advanced engineering.

Purpose and Research Questions

The purpose of this study is to analyze the characteristics of students who have completed one of three pathways of the pre-engineering program at Tulsa Technology Center. The research questions for the study are:

1. What are the factors that influence students' TTC pre-engineering program enrollment?
2. What are the personal, cognitive, and non-cognitive characteristics of students who completed one of three pathways of the TTC pre-engineering program?
3. What are the differences in student characteristics between the three different pathways of completion of the TTC pre-engineering program?
4. What do TTC pre-engineering program students identify as beneficial and/or not beneficial to participating in the program?

Assumptions and Limitations

During this study, the privacy of the participants will be of upmost importance. All participants are volunteers and may withdraw at any time during the study without ramifications. In the beginning stages of data collection and analysis, names will be used to identify participants and to connect multiple pieces of data (survey, archival data, and focus groups) to one participant. After all data has been connected, names will be removed and replaced with unique numbers. Data will be stored in a password protected manner at all times.

This study is limited to the students enrolled in one program at one technology center in the Midwest. The results of this study may not necessarily pertain to other technology centers. The researched sample is even further restrained to students who completed one of the pre-engineering pathways at the TTC STEM Academy during the 2015-2016 school year.

Significance of the Study

The results of this study identified a set of student characteristics that have yet to be collected representing the TTC pre-engineering program. The results indicated the personal and statistical characteristics of students including transcripts, interest inventories, and math self-efficacy. The staff of Tulsa Technology Center could use the results to adjust admission requirements, provide professional development that could increase the diversity of students participating in the pre-engineering program, and support students through the successful completion of their program pathway.

Summary

As the STEM field continues to expand and a retirement trend has been recognized for the near future, it is important that tomorrow's leaders are made aware and are exposed to STEM related careers. Even more crucial is the increase in students who successfully complete STEM education programs. These STEM careers are not easy to qualify for, so current educators are responsible for preparing and equipping students with the necessary skills and knowledge. This study hopes to shed some light on just of many programs preparing students for a career in the STEM field in order to aid in filling the STEM career positions of the future.

This chapter identified a need for the study, theoretical framework, purpose statement, research questions, and the significance of the study. Chapter II will provide a literature review covering the current knowledge and research pertaining to the background and relevancy of this study. The methodology of the study is contained in Chapter III, which includes the research design, setting, participants, data sources, and data collection procedures. Chapter IV will describe the data analysis procedures and results. Finally, Chapter V will summarize the data analysis results and any conclusions that can be made with this study.

CHAPTER II

REVIEW OF LITERATURE

The purpose of this chapter is to provide a synthesis of research literature that forms a foundation for this study. The research questions guiding this study are:

1. What are the factors that influence students' TTC pre-engineering program enrollment?
2. What are the personal, cognitive, and non-cognitive characteristics of students who completed one of three pathways of the TTC pre-engineering program?
3. What are the differences in student characteristics between the three different pathways of completion of the TTC pre-engineering program?
4. What do TTC pre-engineering program students identify as beneficial and/or not beneficial to participating in the program?

Several areas of research are related to this study and will be addressed in this chapter and a summary of research for each area will be discussed. The specific areas of research include contextual teaching and learning, career and technology education, high school pre-engineering programs, and non-cognitive characteristics.

Contextual Teaching and Learning

Humans naturally seek meaning in the world around them. The human brain develops by making connections between new and prior knowledge. Contextual teaching and learning is the natural way of learning and can draw forth a person's full learning potential.

> Contextual teaching and learning is a system of instruction based on the philosophy that students learn when they see meaning in academic material, and they see meaning in schoolwork when they can connect new information with prior knowledge and their own experience. (Johnson, vii)

Students gain meaningfulness when the content is related to a context. The more students can connect their academic concepts with a context, the more meaning and mastery they will gain (Johnson, 2002).

Although this seems like a very different way of presenting material, students connect their knowledge to context every day without even noticing. The knowledge they have is helping them identify problems, investigate, hypothesize, and reach decisions. Whatever the problem, idea, possible solutions, and decisions are the context they are applying their knowledge to. The more time students spend on challenging tasks that are interesting to them, require physical activity, and require higher order thinking, the more their brain will be stimulated (Johnson, 2002).

One of contextual teaching and learning proponents is John Dewey. Dewey believed that the goal of education should be to prepare students for life – a pragmatic view that sought to prepare students for a life of learning and change. In opposition, Charles Prosser posited that education should be divided into two main tracks: academic and vocational. Students who were likely to gain from the rigors of academic education were to remain in the traditional high school while students who didn't fit into that mold were placed on the vocational track to contribute to the country's labor needs. Although Prosser's philosophical stance initially inspired vocational education, Dewey's pragmatic approach to education was eventually embraced (Rojewski, 2002).

During the mid-1980s to early 2000s, education was reforming to raise standards and increase academic achievement. A reverberating theme throughout multiple movements was that all students deserve a quality education, not just students who were planning to go college - thus, the Tech Prep movement - a movement that initiated higher academic standards for all students, even students who were in vocational education and technology programs.

> Young people who meet high academic standards may choose their future. Young people who do not learn demanding academic material will be handicapped in this age of technological wizardry when new inventions dictate human behavior almost as much as thought itself. (Johnson, p. 150)

In a way, these students in the vocational and technology programs were at an advantage. They were on a path to graduate high school with academic knowledge and practical skills, both of which help them make them more productive and successful citizens (Johnson, 2002).

Elaine Johnson's contextual teaching and learning system is comprised of eight parts: making connections that hold meaning, self-regulated learning, doing significant work, collaboration, critical and creative thinking, nurturing the individual, reaching high standards, and using authentic assessment. Self-regulated learning is a student's ability to investigate independent inquiry, whereas collaboration is a student's ability to productively work with others towards a common goal. Both play a critical role in contextual teaching and learning. Teachers want their students to be able to think for themselves, take pride and responsibility for their decisions, and be able to express themselves purposefully to others. Teachers also want their students to be able to communicate, listen, reason, and share leadership roles within a team setting (Johnson, 2002).

Critical and creative thinking are the practical skills necessary for higher order thinking. Critical thinking involves the processes of problem solving, reasoning, organization, and persuasion. Creative thinking provides the originality to possible solutions. Authentic assessment puts learning objectives in a real-world context that uses higher order thinking skills. Through authentic assessment students can display their depth of understand and at the same time, make connections that deepen their understanding (Johnson, 2002). Collectively, these parts make up a meaningful contextual learning environment for students.

Career and Technology Education

Career and technology education began as an alternative to a traditional academic education. Many found that the secondary school was primarily focused on preparing students for college, which was nearly useless for the students bound for a career in the workforce. Career and technology education has grown into much more since its conception – expanding into different fields and even preparing students for college.

This section provides a summary of the history of career and technology education and its evolution.

Early History

Career and technology education began in the form of trade education. As society saw a need for their neighbor's goods and services, and this need became part of their daily life, there was a need for skills of one family member to be passed down to the next generation. The different types of work and the status that came with them created a craving for advancement (Gray & Herr, 1998).

During the Middle Ages, having a set of tools and the skills needed to use them was highly sought after considering the alternative was agriculture or domestic service. The knowledge of these skills was in high demand, but only a select few would emerge with the tools and skills necessary to journey into another job, hence the term journeyman. These highly sought after skills became a source of social and economic status (Gray & Herr, 1998).

As the Europeans began colonizing America, an apprenticeship system was established. Individuals who wanted to learn a skill sought a master of the skill and pleaded to become an apprentice. This apprenticeship was defined as learning and practicing the skill for a set number of years. At the end of an apprenticeship, the trainee would either find work independently or continue to work with his master (Gray & Herr, 1998).

Abuse of this system was inevitable without a defined method of the functions of apprenticeship. Some masters, at the expense of the apprentice, would limit the knowledge they passed on to their apprentice and/or utilize the apprentice for cheap labor, both at the expense of the apprentice. Eventually laws were put into place to discourage such abuse. Apprenticeship became a written, formal agreement that was regulated and enforced by the legal systems. Some laws required the master to teach their apprentice the skills of the trade but also basic literacy skills as well. In some instances, masters would even provide food and shelter. Apprenticeship was also a way to raise orphans, poor children, and delinquents (Gordon, 2014; Gray & Herr, 1998).

Industrial Revolution

The combined effort of the Embargo Act, Non-Intercourse Act, and the War of 1812 spurred the industrial revolution, which slowly dissolved apprenticeship in the United States. Training individuals and small groups of apprentices became impractical with the advent of training large groups of people to work in larger factories in a fraction of the time of an apprenticeship. With factory workers earning more and children attending public school for free, the need for apprentices declined, but this training still had its place in America (Gordon, 2014). Independent shop owners became employees in the bigger manufacturing plants. The technology necessary to keep up with the larger plants was too great for a small shop to undertake. Mass production plants were almost the only lucrative production plants. Educating workers on the entire manufacturing process was now being replaced with many workers trained in how to complete one tiny step of the process. This decreased the time to train an employee and increased production (Gray & Herr, 1998).

During the last quarter of the 19th century, education was a battle between classical education and practical education. As more students began attending school, the classical education format did not fit well (Gordon, 2014). There was a consensus that some kind of workforce education program was going to be necessary if the US was going to grow economically and remain globally competitive. High school, which traditionally served as college preparation, was now housing many different career paths, some that required college education and others that did not.

In 1905, vocational education proponents fought to broaden the traditional curriculum with practical education for the industrial age. Their arguments include the small percentage of students that graduate from high school; nearly all males went to college and females when into white-collar work. America needed to be more competitive in the agriculture and industry markets and the constitution of the US made no provision for control of education (Gordon, 2014).

Philosophies and Education Models

Several ideologies dominated this time of structuring such an education program. Social Darwinism suggested that students be evaluated early to determine which occupation will fit best. Their future education was then tailored towards this occupation. Dualism was slightly broader than Social Darwinism, as it defined students as being gifted in the manual arts or in intellect abilities. Like Social Darwinism, these gifts guided the structure of their future education (Gray & Herr, 1998).

Taylorism divided manufacturing training into small increments so that workers could be trained quickly. Henry Ford was a proponent of Taylorism and his assembly line structure became very popular. Ford was known to brag that he could train his workers in less than a day. Henry Ford’s idea of narrowing down the education of his workers bled into the education system. Education institutions worried that the curriculum they were providing their students was not relevant to their students' futures. Very few students were going into professional occupations, such as management of an assembly line. Most students were going to be working on the assembly line and needed only basic literacy skills. This type of education structure led to the US having the best higher education system and the worst workforce education system (Gray & Herr, 1998).

At the beginning of the 20th century, less than 15% of school-aged children were being educated in a public school. The intentions of vocational education were to reach some of the other 85% (Gordon, 2014). Many urban high schools were beginning to incorporate some type of manual arts in the curriculum. Larger schools even had some business education courses available to students. There was a need for agricultural education in many schools, as many agricultural families wanted their children to work on the farm. Home economics became a program to help students understand and learn the basics of home management. These additional course offerings seemed like a great start to vocation education, but unfortunately, the curriculum was not rigorous enough to prepare students to become skillful workers. The business program evolved into secretarial work and the home economics program became an education to keep women from leaving the home for work. The question about how to incorporate vocational education into the school system was still unanswered (Gray & Herr, 1998).

Three main education models emerged. One was the dual system modeled after Germany's education system. In the dual system, the vocational education was completely separate from the traditional academic education. Business owners led the vocational schools and encouraged students to transfer to vocational school by the eighth grade or earlier, thus completely withdrawing from traditional education. Another model incorporated vocational education into the existing schools, available exclusively to high school juniors and seniors. This model kept that vocational education parts under the administration of educators. A third model relied on businesses to provide on the job training for half of the day while students attended traditional school the other half of the day (Gray & Herr, 1998).

Of the three models, the one that integrated vocational education into the traditional education system and still under the administration of educators thrived the most and led to the passage of the Smith-Hughes Act of 1917. The Smith-Hughes Act placed vocational education in the high schools and under the control of the educators and school boards. It also required the states to have a separate state board for vocational education to manage the funding allotted to vocational education programs. This structure of workforce education lasted into the 1990s (Gordon, 2014; Gray & Herr, 1998).

Twentieth Century

Education focused on the needs created by World War I. America needed to train thousands of inexperienced civilians fast. Students were taught through vocational education, although it was not universally defined, but was a necessary change for preparing workers. By the end of WWI, 62,161 people were trained for some type of war production job. World War II brought about more changes to vocational education. Due to the large numbers of men leaving for the military, industries invited women to vocational training to help. In 1941, 11,552 women had been trained to help the war effort. By 1943, 741,332 women had enrolled in training programs (Gordon, 2014).

From 1917 to 1963, there was a pressing need for more trained workers. As soldiers returned from war, there was a need for adult vocational training for employable skills. Vocational education advocators also wanted to retain more students in secondary education. These led to an increase in vocational education programs and increased funding for programs. The focus was on agriculture, industry and home economics for high school students (Gordon, 2014).

From 1963 to 1968, vocational education advocates fought to expand their programs. The Vocational Education Act of 1963 ensured that vocational education was an equal opportunity for all people of all ages. They obtained funding to research and develop the curriculum for new programs. Reginal vocational schools were becoming popular and vocational education was extended to be offered to adults outside or war training. Amended in 1968, the Vocational Education Act included vocational education as postsecondary education. Vocational education was expanding and establishing itself and receiving more attention and funds for a more equal education for all students and student needs. The Carl. D. Perkins Vocational Education Act of 1984 eventually replaced this act. The Carl Perkins Act served two major purposes: to improve the skills of workers for job opportunities and equal access for adults in vocational education (Gordon, 2014).

The Nation at Risk report came out in 1983 and was a product of President Ronald Reagan's National Commission on Excellence in Education. This report started an educational reform across the US. The findings indicated that the US was losing its international competitive edge and attributed this loss to the low standards and poor performance of the US education system. There was a need to increase the current education system with more course requirements, longer school days, more stringent college entrance requirements and an emphasis on standards for students and teachers. There was also a need to restructure the organization of schools as well as the whole educational process in general (Gordon, 2014).

The Carl D. Perkins Vocational and Applied Technology Education Act of 1990 brought more changes and a new name to vocational education. This act amended the previous act of 1984. The goals of this act were to better integrate academics and vocational education as well as make the transition between secondary education and post-secondary education and/or work for fluid. This new act required the development of performance standards and measures for secondary and post-secondary vocational and technology education. In 1990, the American Vocational Association defined technology education as "an applied discipline designed to promote technological literacy which provides knowledge and understanding of the impacts of technology including its organizations, techniques, tools, and skills to solve practical problems and extend human capabilities in area such as construction, manufacturing, communication, transportation, power, and energy" (Gordon, 2014, p. 245).

In 1996, vocational education established career clusters to increase the mobility of graduates. The goal of these career clusters was to create curriculum frameworks that would guide students through a progression of courses that would prepare the student for the transition from secondary school to post-secondary school or employment. Each career cluster has a pathway of more specific skills and knowledge requirements for different employment levels (Gray & Herr, 1998). The 16 career clusters are as follows:

- agriculture, food, and natural resources,
- architecture and construction,
- arts, audio/video technology, and communications,
- business, managements, and administration,
- education and training,
- finance,
- government and public administration,
- health science,
- hospitality and tourism,
- human services,
- information technology,
- law, public safety, corrections, and security,
- manufacturing,
- marketing,
- STEM – science, technology , engineering, and mathematics, and
- transportation, distribution, and logistics.

The Perkins Act of 1998 brought about more changes to vocational and technical education. This act required that each state establish its own set of education standards in order to create a more unified education system. This act also established the official Tech Prep program. Initially, Tech Prep was a combination of two years of secondary education and two years of post-secondary education. Tech Prep increased the rigor of vocational/technical education by integrating academic and vocational/technical instruction, provides competence in academic areas outside of vocational/technical education, and lead to certificates, associate or baccalaureate degrees, employment, and further education. Tech Prep provides technical preparation in fields such as engineering technology, applied science, practical trade, agriculture, and business. The course work for tech prep programs focus on higher-order thinking skills, developing students' problem solving skills, and teaching students how to learn (Gordon, 2014; Gray & Herr, 1998).

The year 2006 brought about the change of the term vocational education to career and technology education in laws. The Perkins Act of 2006 required more standards, accountability, and program improvement as well as a focus on more rigorous academics and business and industry. This act also provided funding for career academies, career clusters, technical assessments and data systems, recruitment, and retention of educators. Career and Technology Education (CTE) schools and classes now had to define their programs of study. Programs of study had to include the academic and CTE courses as a course progression, the possible post-secondary credit or industry-recognized certification available, and the current emerging occupations for the program (Gordon, 2014). The U.S. House of Representatives reauthorized the Perkins Act June 22, 2017. This passage reauthorized the Perkin Act through 2023 (ACTE, 2017).

As some states started creating college and career ready pathways in their high schools, so did CTE. College and Career ready is defined as

> A high school graduate has the knowledge and skills in English and mathematics necessary to qualify for and succeed in entry-level, credit-bearing postsecondary coursework without the need for remediation -- or put another way, a high school graduate has the English and math knowledge and skills needed to qualify for and succeed in the postsecondary job training and/or education necessary for their chosen career (i.e. community college, university, technical/vocational program,

apprenticeship, or significant on-the-job training). (Atlanta Public Schools, 2016, para. 2).

Oklahoma Career and Technology Education

The Smith-Hughes Act of 1917 provided funding and support for the promotion of agriculture and the trade industries education, including teacher training. Just weeks after this act passed, Oklahoma agreed to the terms and conditions in order to receive federal funding for such programs. At that time, the definition of vocational education was “the preparation for employment in positions requiring less than a baccalaureate degree” (Oklahoma Department of Career and Technology Education [ODCTE], 2006, p. 4).

Oklahoma was not alone in joining the vocational education movement, but it was one of the more eager states to start the implementation process. The first vocational education program opened up in 1964 in Tulsa, OK. At the time, the school was acting mostly through Tulsa Public Schools. Other area schools began appearing over the next few years in Oklahoma City, Ardmore, Duncan, and Enid (ODCTE, 2006).

In May 1966, the voters of Oklahoma chose to allow one or more school districts to come together and create vocational school districts. These district schools were required to elect their own vocational school board and well as be responsible for the buildings and the maintenance required. The first district vocational school formed was Tri-County Technology Center in Bartlesville (ODCTE, 2006).

The Oklahoma Career Technology system operates in four different delivery systems. CTE teachers and curriculum can be found in comprehensive schools, technology centers, business and industries, and skills centers. Comprehensive schools are those that teach any of the grades K-12. Technology centers are separate from the public schools and welcome high school students and adults. Business and industry utilize CTE for training while skills centers are education programs for inmates and juvenile offenders. With these four areas of operation, the Oklahoma CTE system reaches many, if not most of the citizens of Oklahoma (ODCTE, 2006).

Oklahoma's Department of Career and Technology is comprised of 29 technology schools, cumulating to 58 campuses across 72 of the 77 Oklahoma counties. These technology centers serve local high school students and adults. Education offered comes in the form of full-time career majors, part-time classes, short-term courses and industry specialized training. High school students attend technology centers free of charge, while adult students are required to pay tuition to offset some of the cost. In FY 16, the technology centers served 19,951 high school students and 511,512 adults with 2,640 full-time teachers (ODCTE, 2016).

Tulsa Technology Center (TTC) was founded in 1965 and is Oklahoma's largest technology school. In 1973, TTC became an independent public school district with one campus – Lemley. Since then, TTC has expanded to six campuses throughout Tulsa County. TTC provides services for high school students in 14 surrounding school districts, as well as home-school and private school students. High school students are not charged tuition and are provided with free transportation to and from their high school. TTC also provides learning opportunities for adults and specialized training for business and industries. In FY 14, TTC had over 3,000 high school students and just over 1,500 adult students (Tulsa Technology Center, 2016a).

Tulsa Technology Center offers 13 of the Career Clusters established by the Oklahoma State Department of Career and Technology Education -

- architecture and construction,
- arts, audio/video technology, and communications,
- business, managements, and administration,
- finance,
- health science,
- hospitality and tourism,
- human services,
- information technology,
- law, public safety, corrections, and security,
- manufacturing,
- marketing,
- STEM – science, technology , engineering, and mathematics, and
- transportation, distribution, and logistics.

Within the 13 career clusters are 73 different career majors, with 51 available to adult students and 57 available to high school students (Tulsa Technology Center, 2016b). High school students also have the opportunity to earn mathematics and science credits that can be used towards the state requirements for graduation (Tulsa Technology Center, 2016a).

For this study, the career major in STEM being studied is Pre-Engineering. In addition to this career major, two other career majors are considered STEM career majors, but are not part of the current study. ODCTE has approved instructional frameworks that technology centers can offer. The career pathways for Pre-Engineering are all based on the Project Lead the Way curriculum.

High School Pre-Engineering Programs

As the number of engineering jobs continues to rise, the number of engineering majors in colleges should be rising as well. Unfortunately, this is not that case for many reasons, including insufficient academic preparation and lack of awareness of what the career of an engineer entails. In order to boost the number of engineering majors, many organizations and curriculums have been developed for high school students (Hirsch, Kimmel, Rockland, & Bloom, 2005).

Some high schools and districts have collaborated and created their own engineering curriculum. As an alternative, some organizations developed pre-engineering curriculums for schools to adopt and teach. Two of the best-known nationwide high school pre-engineering curriculums are Project Lead the Way (PLTW) and Engineer Your World (EYW).

Project Lead the Way is a curriculum that spans kindergarten to 12th grade. PLTW's stance is that all students need real world and applied learning in order to succeed in college and career. The curriculum exposes students to a broad spectrum of engineering careers and reinforces problem solving, critical thinking, and communication throughout. In order to teach one of PLTW's courses, teachers must attend a one to two week intense training that walks them through the problem- and project-based curriculum by trained and experienced teachers (Project Lead the Way, 2017).

Engineer Your World is a student-centered curriculum for students in grades nine through twelve. Like PLTW, EYW provides a hands-on curriculum that is project-based and applicable to the real world. EYW students experience a wide variety of engineering fields and authentic engineering challenges. Within each challenge, students develop engineering skills such as the engineering design process and logical thinking and decision-making (University of Texas, 2017).

Retaining college engineering students has been a challenge seen across the nation. Colleges and universities cannot seem to keep up with the demands of industry. Cole, High, and Weinland (2013) investigated one method to increasing the number of engineering majors at one college. Cole et al. looked at the persistence of Oklahoma State University engineering students who completed a pre-engineering program at an Oklahoma regional technology center to engineering students how did not complete a pre-engineering program at an Oklahoma regional technology center. The results of this study indicate that although the pre-engineering program may have positively affected enrollment and persistence, the rate of persistence is very close to the persistence rate of students who did not complete a pre-engineering program (Cole, High, Weinland, 2013).

A study by Lenin and Wyckoff (1990) sought to identify student characteristics that led to persistence and success in engineering. The goal was to use the data to help improve methods of and inform academic advisors that communicate with students considering an engineering degree. Data were collected from just over 1,000 freshmen in the College of Engineering at Pennsylvania State University. Results indicated that not a single factor predicted success over time. However, characteristics could be identified if time was divided up into three intervals: pre-enrollment, freshmen year, and sophomore year. The best predictors for pre-enrollment were high school GPA, gender, and reason for choosing an engineering major. The predictors for freshmen success were Physics I, Calculus I, and Chemistry I course grades. Sophomore success predictors included Physics II, Calculus II, and Physics I (Lekes, et al., 1990).

Zhang, Anderson, Ohland, and Thorndyke (2004) also conducted a study to identify factors that lead to students successfully completing an engineering degree. The data collected came from students over a 15-year span and came from nine universities. Using a multiple logistical regression, Zhang, et al. found that high school GPA and SAT mathematics scores positively correlated with the likelihood of graduation (Zhang, Anderson, Ohland, & Thorndyke 2004).

A Midwest university conducted another study with 3,459 science, technology, engineering, and mathematics (STEM) students. LeBeau et al. (2012) analyzed high school and student characteristics and how those characteristics may contribute to the successful completion of a STEM degree. High school characteristics did not seem to have much of a correlation with completion. On the other hand, students' ACT math score, gender, and high school mathematics GPA had a positive correlation (LeBeau et al., 2012).

A study by Honken and Ralston (2013) took a look at first-time, full-time freshman as an engineering college and analyzed the characteristics of students that left the major or university after one and two semesters. The survey was given to freshman entering the college the fall of 2010 and included 296 students. After a 92% response rate, the study found that six of the students left the university after one semester. These six students came in with an average high school GPA of 3.34 and average ACT composite core of 24.8. The six students left the university with an average GPA of 0.59.

Twenty-three students changed their majors after one semester: their data was not significantly different from the students that remained in engineering. After one year, the retention rate was 76%. Students who left the university or changed their major identified their lack of interest in engineering and lack of math and science preparation as factors that led to the change. Students that persisted tended to know an engineer (Honken & Ralston, 2013).

Marra, Tsaim, Bogue, and Pytel (2015) analyzed factors that contributed to students' successful completion of a two-year engineering program at 19 two-year college campuses. This study looked at quantitative statistics like the other studies previously mention, but this study also included peer-to-peer relations and peer-to-instructor relations as part of their analysis. This study found that the students' commitment to engineering positively correlated with student-student relations, student-instructor relations, and cumulative GPA. Students' general engineering knowledge was found to be positively correlated with students' SAT score upon entry to the college (Marra, Tsaim, Bogue, & Pytel, 2015).

The above studies have investigated what factors can lead to a college engineering student's success. Factors that positively contribute to completion of an engineering degree in the above studies include completing a pre-engineering program (Cole, High, Weinland; 2013), high school GPA (Lekes, et al., 1990; Zhang, Anderson, Ohland, & Thorndyke 2004; LeBeau et al., 2012; Honken & Ralston, 2013; Marra, Tsaim, Bogue, & Pytel, 2015) and peer-to-peer relations (Marra, Tsaim, Bogue, & Pytel, 2015).

Non-Cognitive Student Traits

Traditionally, course grades and standardized test scores are used to predict college success. So much that most U.S. colleges have a minimum Scholastic Aptitude Test (SAT) or American College Test (ACT) score that must be achieved for acceptance. Contrarily, these test scores have very little to do with the prediction of college course success. Rather, non-cognitive traits, such as parental support and intrinsic motivation, might add to the standardized test scores to better predict a students' likelihood of collegiate success (Ransdell, 2001). This study will look at three specific non-cognitive traits: self-efficacy, grit, and mindset.

Self-Efficacy

Bandura (1977) presented a framework in which self-efficacy plays a key role in a person's behavior, which has a direct effect on a person's outcomes. The strength of one's self-efficacy determine whether one will attempt needed behaviors in order to achieve certain outcomes. If the situation that must be encountered is threatening or too difficult, a person is likely to avoid the situation. On the other hand, if a person is confident in their abilities to produce the needed behavior for a desired outcome, they are likely to put forth the effort and try to achieve their goal. Those who continually subject themselves to threatening situations that have the desired outcomes will build on their confidence and self-efficacy for future situations and goals, while those who prematurely turn away from threatening or difficult situations will continue to withdraw from the situation and keep their lower self-efficacy for a long time (Bandura, 1977).

Self-efficacy comes from primarily four sources – performance accomplishments, vicarious experiences, verbal persuasion, and physiological states. Each of these four sources is likely to affect one's self-efficacy differently, some having a stronger impacts than others do (Bandura, 1977).

The first source listed – performance accomplishments – is very likely to have the greatest impact of the four sources. This source of efficacy is based on the mastery and successes of a person. The greater the number of successes a person has accomplished, the more their self-efficacy is positively impacted. Repeated failures, especially failures early in the process, tend to have a negative impact on one's self-efficacy, but failures that are later overcome with success can strengthen a person's self-efficacy and their persistence to master future goals that are similar as well as different from the achievement that was just mastered (Bandura, 1977).

Vicarious experience is seeing others achieve outcomes that seem threatening or difficult by another person. Watching others succeed without adverse consequences shows that the goal can be achieved with persistence and effort. This source of self-efficacy is likely to be less impactful than personal achievements, but still impactful nonetheless. It is more meaningful for observers to see others struggle and overcome obstacles before succeeding rather than watching someone easily master a seemingly difficult task. It is also a good idea to see different models achieve what seemed to be difficult tasks. These kinds of observations show how determination, effort, and persistence can lead to success (Bandura, 1977).

Verbal persuasion and emotional arousal are the final two sources of self-efficacy. These two probably have the least amount of impact on one's self-efficacy. Verbal persuasion is the act of suggesting that one can accomplish a given task. This source is more likely to make a difference in a person with some self-efficacy rather than little to no self-efficacy. Verbal persuasion is also less likely to affect a person who hears suggestions that contradict past attempts at the same task. Emotional arousal encapsulates anxiety, stress, and confidence. Too much thought about a task can lead to high stress, high anxiety, and even high confidence that can hinder achievement. A person is more likely to be successful if they are relaxed and un-agitated when attempting the task at hand. People who believe they can achieve their goals are less likely to generate fearful thoughts in difficult situations (Bandura, 1977).

In a longitudinal study, Larson et al. (2015) explored the correlation between mathematics/science self-efficacy at the beginning of a college major and the likelihood of completing said major. The sample included 280 college students taking an introductory science course their first year at a Midwest university. Students took the survey the first month of the science course. Mathematics/science self-efficacy positively correlated with graduation four to 8 years after the survey. Moreover, mathematics/science self-efficacy was more of a predictor than prior achievement and mathematics aptitude (Larson, et al., 2015).

Carroll, et al. (2009) proposed that academic, social, and self-regulatory self-efficacy are positively correlated with academic achievement. The study included 935 students ages 11 to 18 from 10 secondary schools. The results of the study show that academic self-efficacy has a very strong relationship with academic achievement (Carroll, et al., 2009).

A second study investigates the relationship between self-efficacy and academic achievement. This study's data was collected from 250 high school students during the 2010-2011 school year. The results show that self-efficacy can be used as a predictor for academic achievement. Even more, self-efficacy sub-factors (self-evaluation and self-regulation) are two of the best predicting factors of academic achievement (Motlagh, Amrai, Yazdani, Abderahim, & Souri, 2011).

The MSES-R can be used to assess an individual's mathematics self-efficacy. Betz and Hackett (1983) developed the MSES-R to assess undergraduate college students' mathematics self-efficacy. The MSES-R has 52 items and three subscales that participants rate their confidence to: solution of math problems, completion of math tasks, and satisfactory completion of mathematics college courses and science college courses requiring mathematics knowledge (Pajares & Miller, 1995). Individuals rate their confidence on a five point Likert scale from 1 = not confident at all, to 5 = very confident.

Grit

Grit is defined as "perseverance and passion for long-term goals" (Duckworth, Peterson, Matthews, & Kelly, 2007, p. 1087). If there were two students of the same intelligence, chances is one will accomplish more than the other is. The difference is their level of grit. A grittier person is more likely to maintain interest in a long-term goal and put forth the effort to reach that goal despite failed attempts and lack of sufficient visual progress. A less gritty person will likely change their trajectories and goals when confronted with failure or adversity (Duckworth et al., 2007).

Wolters and Hussain (2015) published a study that looked at the relations between grit and self-regulatory learning and academic achievement. Self-regulated learning can be described as the management of motivational, cognitive, and behavioral aspects of their own learning. Wolters and Hussain (2014) collected an online survey from 213 college students from a large public university. Results indicated one of the aspects of grit, self-perseverance of effort, was a predictor of self-efficacy and other self-regulating learning factors such as cognitive and motivational management. The study's conclusion is that students' grit positively influenced their self-regulated learning, which in turn positively influenced their academic achievement (Wolters & Hussain, 2015).

In another study about grit, Strayhorn (2014) compared grit to the academic success of Black males at predominately White universities. The study included 140 Black male students enrolled full time at a southeastern university. Most of the participants were first-generation college students. Data was collected via a survey during the spring semester of 2008. The data analysis revealed that grit did indeed positively relate to the academic success of the Black males. In fact, grit was a better predictor of academic success than more traditional measures of academic ability such as high school GPA and ACT scores.

Joanne Rojas and Ellen Usher (2012) collaborated on a study that uncovered a correlation between grit and mathematics achievement. They looked at students in the fourth through eighth grade at three elementary schools in the U.S. Grit was measured using 10 items from Duckworth and Quinn (2009). Mathematics achievement was measured using a teacher assessment and mathematics report card grade. This study found that the students' level of grit positively correlated with their mathematics achievement (Rojas & Usher, 2012).

Duckworth et al. validated a 12-item grit measurement instrument with a series of studies which included levels of grit positively correlated with high levels of education, higher SAT score, retention of cadets at West Point and admittance to the Scripps National Spelling Bee. Six of the items measure consistency of interest, while the other 6 items measure perseverance of effort – both of which contribute to an individual's level of grit. All items are measured on a 5-point Likert scale from 1 = not at all like me, to 5 = very much like me (Duckworth, et al., 2007).

In a later study, Duckworth and Quinn (2009) validated a shortened version of the grit instrument. This 8-item instrument was subjected to a similar battery of studies and was found to be a more efficient measure of grit. The shortened grit scale included four items measuring consistency of interest (reverse scale) and four items measuring perseverance of effort, all eight still measured on five point Likert scale as described above. The final score is calculated by finding the average of the eight items. The resulting score will range from 1, meaning not gritty, to 5, meaning very gritty. The items in the shortened version of the grit scale are questions 5-12 on the survey provided (See Appendix D).

Mindset

Mindset, also known as the implicit theory of intelligence, is one's belief of the malleability of one's own intelligence and morality. A person with a growth-mindset believes that a person's basic qualities can change based on effort. A person with a fixed-mindset believes that they are born with qualities and nothing can change those abilities. People with a growth mindset believe it is impossible to see what can be accomplished, for them, anything is possible. In fact, people with a fixed-mindset may appear to be optimistic and intelligent, but it is when people are faced with difficulty or even failure that their mindset will show (Dweck, 2006).

Blackwell, Trzseniewski, and Dweck (2007) conducted a study comparing students' mindsets and academic achievement. This study included four waves of students entering seventh grade and continuing until eighth grade. Data was collected measuring their implicit theories and other achievement-related beliefs at the beginning of each school year. Data was ultimately collected from 373 students at a secondary school in New York City over a five year period. Other data about the students was collected including mathematics achievement scores and mathematics course grades. Blackwell, Trzeniewski, and Dweck (2007) found that when these students embrace the theory that intelligence is malleable (growth mind-set) tended to have stronger learning goals and higher mathematics achievement scores.

Paunesku et al. (2015) suggested that by holding an intervention teaching students that their mind is a muscle and always growing and changing, or in other words, that intelligence is malleable. This intervention took place in 13 high schools across the U.S. Students' GPA was calculated at the end of the fall semester, the two 45 minute online intervention took place at the beginning of the spring semester, and GPA were calculated again at the end of the spring semester. This data showed increased achievement in underperforming students over a semester. These results were consistent in all of the 13 schools that participated (Paunesku et al., 2015).

Students with a growth mindset tend to strive to achieve learning goals whereas students with a fixed mindset tend to put effort towards validating their intelligence. A study by Grant and Dweck (2003) college students grades in an organic chemistry course were compared to their results of their perceived abilities and how they set their goals. The analysis showed that students with a growth mindset achieved higher final grades in the course after controlling for their ability prior to taking the course. The students who held a fixed mindset seems to be troubled but a low assessment score early in the course and failed to fully recover their grade before the final exam (Grant & Dweck, 2003).

Mindset has also been assessed on an international scale. The Program for International Student Assessment (PISA) collects data every four years from millions of students worldwide. Among the many items in the 2012 assessment are items that assess mathematics skills, beliefs about mathematics, and mindsets. The data analysis showed that the students with the highest mathematics scores are also the students with a growth mindset (Program for International Student Assessment [PISA], 2014).

Mindset can be measured with four questions where individuals rank their degree of agreeableness on a scale from 1 to 6, 1 = strongly disagree and 6 = strongly agree. Two of the questions ask whether the participants believe intelligence is malleable, and two of the questions ask whether the participants believe intelligence is fixed (these are reverse scored). The questions are not content-specific but rather about learning and knowledge in general. A final mindset score is found by calculating the mean of the four questions. These items were drawn from Carol Dweck's (2006) book, *Mindset: The New Psychology of Success* and have been reported with internal reliabilities between .78 and

.98 and test-retest reliabilities ranging from .77 to .80 (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, Chiu, & Hong, 1995; Esparza, Shumow, & Schmidt, 2014).

Summary

Career and technology education (CTE) has greatly evolved over the past century. Now, students in a career and technology education can be ready for a career with licenses and certificates, or prepared for a college degree program of study. As a state, the Oklahoma State Department of Career and Technology Education saw a need and adopted pre-engineering as one of the many career paths that are offered statewide. With these gains, Oklahoma's students are offered to opportunity to learn and prepare for a career in engineering.

Preparing students for a rigorous degree such as engineering is only one of the many ways the education field can contribute to increasing the number of STEM qualified employees for the fast growing field of engineering. This study is focused on the success of students though the pre-engineering program. Along with transcripts and application for admissions information, the non-cognitive traits of students who completed a pre-engineering pathway will be assessed. The non-cognitive traits being measured are grit, mindset, and mathematics self-efficacy. These traits, along with other archived data collected, will paint an image of students who successfully completed a pre-engineering pathway and hope to inform current practices and future decisions.

This chapter provided a synthesis of research literature that provided a foundation for this study. The following chapter will first give a rich description of the setting and participants. Later in Chapter III the data collection procedures and the data analysis that follows. Finally, trustworthiness and ethical considerations will be discussed.

CHAPTER III

METHODOLOGY

This study sought to describe the characteristics of students and their experiences at Tulsa Technology Center's (TTC) pre-engineering program. Chapter three describes the research design, the setting, the participants, and the data analysis procedures. The research questions guiding this study were:

1. What are the factors that influence students' TTC pre-engineering program enrollment?
2. What are the personal, cognitive, and non-cognitive characteristics of students who completed one of three pathways of the TTC pre-engineering program?
3. What are the differences in student characteristics between the three different pathways of completion of the TTC pre-engineering program?
4. What do TTC pre-engineering program students identify as beneficial and/or not beneficial to participating in the program?

Gaining a better understanding of students who choose to participate in the pre-engineering program and the supports they found beneficial can help TTC program instructors, TTC administration, and other programs across the country address the needs of the students and consider needed program changes.

Research Design

A mixed methods research design guided this study. Creswell (2008) defines mixed methods research as "a procedure for collecting, analyzing, and 'mixing' both quantitative and qualitative research and methods in a single study to understand a research problem" (p. 552). When quantitative or qualitative methods are not sufficient in answering the research questions, researchers use mixed methods research designs to provide a better understanding of the research problem.

Specifically, this study utilized a concurrent triangulation mixed methods with follow up interviews. A concurrent triangulation mixed methods research design collects quantitative and qualitative data simultaneously. The quantitative and qualitative data are analyzed separately, then the results are combined and final themes are formed (Creswell, 2008).

Mixed methods research designs come with both strengths and weaknesses. Because of the nature and differences between quantitative and qualitative data analysis and the weight of each type of data's influence on the research questions, a single philosophical framework can be difficult to identify. Further, the analysis of the two types of data requires the researcher to perform data transformation to integrate and compare the two different data sets. However, the strengths of mixed methods research designs include being able to utilize instruments that are more sensitive in gathering data and provide more descriptive conclusions for the research questions (Creswell, Plano Clark, Gutmann, & Hanson, 2003).

Setting

This study focused on one pre-engineering program. This section will describe the pre-engineering program, the curriculum used in the courses, and the three different pathways to completion, and the student selection process.

Tulsa Technology Center's Pre-Engineering Program

Beginning in the late 1990s and early 2000s, the need for more engineers continues to climb (ACTE, 2009). As a school that prepares students for the workforce, Tulsa Technology Center (TTC) began looking into adding a pre-engineering program. The pre-engineering program at TTC began in August of 2004 with two instructors; one instructor stationed at a TTC campus and served high school juniors and seniors, and one instructor served high school freshman and sophomores at two area high schools. Since then, the pre-engineering program has expanded to 17 instructors - eight instructors serving juniors and seniors on the TTC campus called the STEM Academy, and nine instructors serving freshman and sophomores at eight area high schools (considered off-site programs). In 2004, about 100 students enrolled in the program and by 2015, the program had expanded to approximately 1100 students. This study focused on the students that enrolled and completed one of the pre-engineering pathways on the TTC STEM Academy campus during May 2016.

Curriculum

Each academic year, students at the STEM Academy enroll in three courses - two engineering courses and one mathematics or science course. The mathematics courses offered are pre-AP pre-calculus, AP calculus AB, and AP calculus BC. The science courses offered are AP physics I, AP physics C, AP biology, and AP chemistry. Appendix A describes the engineering courses which are from the Project Lead the Way (PLTW) pre-engineering curriculum.

PLTW is a nonprofit organization that has become the nation's leading provider of K-12 science, technology, engineering, and mathematics (STEM) education program. PLTW courses are project-based courses that give students the opportunity to discover, learn, and solve real life engineering problems. All PLTW pre-engineering instructors must attend an intense two-week training in order to have access and qualify to teach the curriculum. It is through this training process that PLTW ensures its legacy and success (PLTW, 2017).

The philosophy of PLTW is to provide students "access to real-world, applied learning experiences that empower then to gain the skills they need to thrive in college, career, and beyond" (PLTW Our approach, p. 1). The program intends for students to develop skills such as critical thinking and collaboration. With the rich activities and project-based learning instructional style, students engage in a contextual learning environment that fosters applied knowledge and practical applications (PLTW Our approach, 2017)

Specifically, the PLTW pre-engineering program "empowers students to step into the role of an engineer, adopt a problem-solving mindset, and make the leap from dreamers to doers" (PLTW Our programs, p. 1). The curriculum applies relevant and real-world applications in order to solve challenging problems. The skill developed in this program, such as collaboration, communication, and perseverance, will be useful for the rest of their lives, no matter their chosen career path (PLTW Our programs, 2017).

The PLTW pre-engineering program begins with two foundation courses: Introduction to Engineering Design (IED) and Principals of Engineering (POE). IED and POE serve as introductory courses and prerequisites for the elective engineering courses. Some students have the opportunity to take IED and POE before enrolling at the STEM Academy. In that case, the students enroll in two elective engineering courses.

After the two foundation courses are completed, TTC students can choose from PLTW's elective engineering courses. TTC offers the following PLTW courses: aerospace engineering, civil engineering and architecture, computer integrated manufacturing, computer science and software engineering, and digital electronics. Appendix A describes each course. STEM Academy seniors that have previously completed IED and POE enroll in the capstone course: engineering design and development (Tulsa Technology Center [TTC], 2015). Figure 2 provides a course progression map. The capstone course represents a culmination of all the engineering knowledge gained throughout the program and sets students up to identify, research, design, and test a solution to a real-life problem. Students exercise professional and documentation skills to emulate the experiences of an engineer (PLTW, 2017).

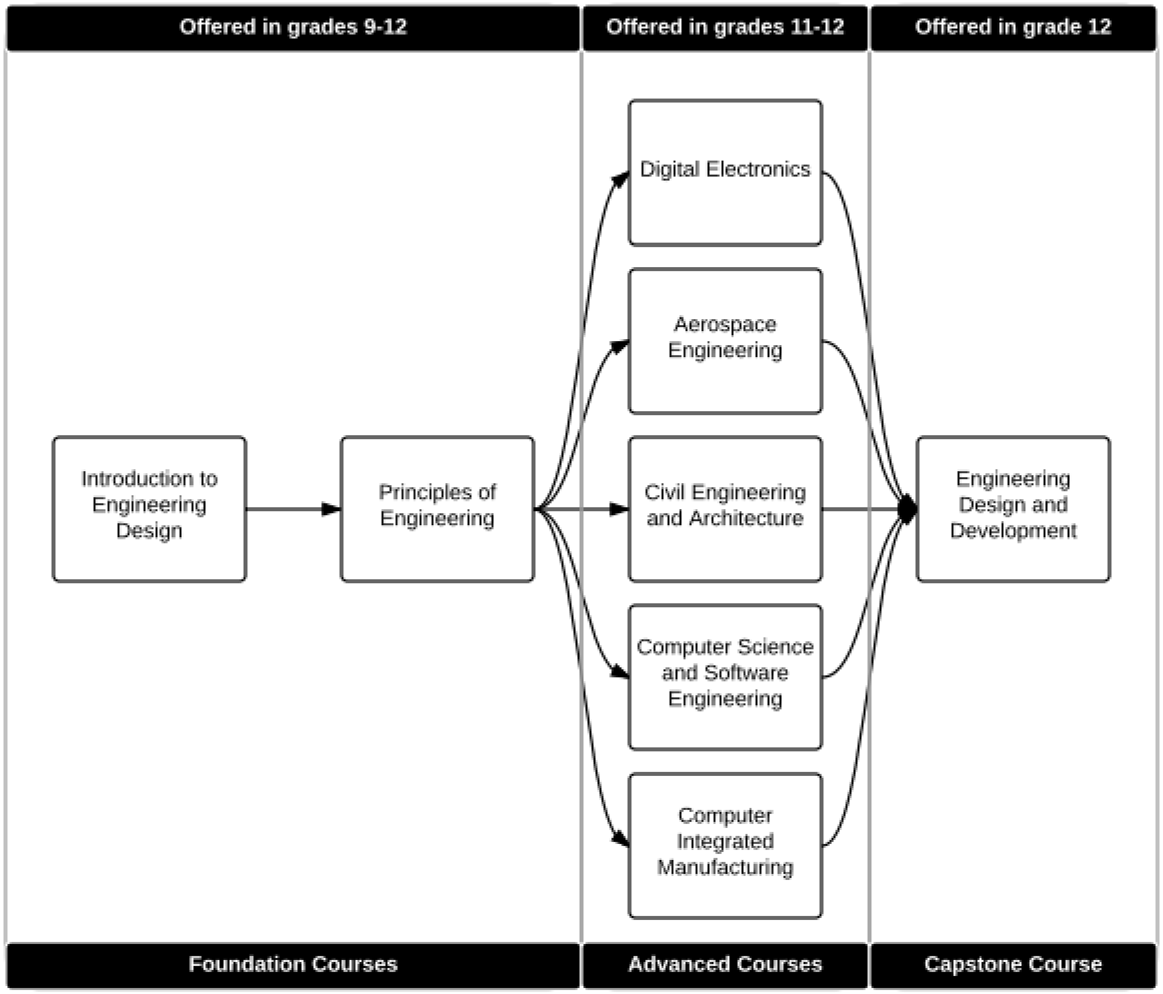

Figure 2. TTC's pre-engineering course progression.

Pre-engineering Pathways

Students can complete TTC's pre-engineering program via three different pathways. At the most basic level, students who complete IED and POE are completers of the Foundations of Pre-Engineering pathway. If students complete the two foundation courses, one advanced engineering course, and the capstone course, they are a completer of the Pre-Engineering pathway. If students complete the two foundation courses, three advanced engineering courses, and the capstone course, they are a completer of the Advanced Pre-Engineering pathway. Figure 3 illustrates these pathways.

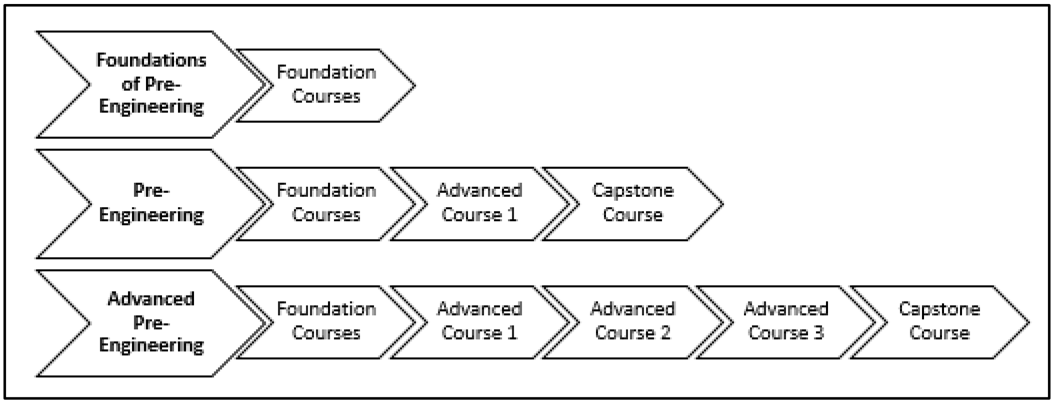

Figure 3. TTC's pre-engineering pathway options.

Student Selection

The students who apply to come to the STEM academy are one of two types of students: new or continuing. New students are students who have not previously completed any of the PLTW pre-engineering courses. In order for new students to apply for entrance into the STEM Academy pre-engineering program, they must fill out a TTC application for admission. On this application, students fill out some basic information about themselves, select which program they are interested in, and complete a career-cluster-interest survey.

The career cluster interest survey is intended to give students an idea of what career clusters they may enjoy exploring. There are 16 boxes containing items that may describe a student. Students circle the items that best describe themselves, and then total that number for each box. After totaling the boxes, survey suggests that students look at careers within the career clusters in which they scored the greatest. Each box corresponds to a career cluster. Appendix B provides an admissions application and career-cluster-interest survey.

New students must also complete a program tour at the STEM Academy. This requires students to visit the STEM Academy and follow an instructor-guided tour through the pre-engineering classrooms and allows them to visit with their potential instructors.

Continuing students are students that have taken one or two of the PLTW pre-engineering courses offered by TTC at their high school. These students have already filled out the application mentioned previously when they enrolled in the TTC PLTW course at their high school. Continuing students fill out a continuing enrollment form to let TTC know that they wish to continue the pre-engineering program at the STEM Academy. These students are not required to take a program tour like the one the new students are required to complete.

After students have submitted an application or a continuing enrollment notice, TTC's student services (new students) or TTC's pre-engineering counselor (continuing students) collect a high school transcript. The student services or the counselor checks the transcripts for math courses, grades, and reading and math scores, depending on the grade the student is entering.

This study focused on students who completed one of pathways of the Pre-Engineering program May 2016. Since students could have entered the program their ninth, tenth, eleventh, or twelfth grade year, the admissions requirements are slightly different from grade to grade. Entering ninth and tenth grade students do not have any pre-requisite courses or test scores. Rather, the admissions office awards students points for math courses and grades earned and depending on their math courses and grades earned. The next section describes this process in detail. Entering eleventh and twelfth grade students must have at least 10 academic points from the reading and math parts of the ACT, ACT PLAN, ACT Explore, or TABE-D exams. Figure 3 describes the academic points for these tests. These students also have to have passed algebra I and geometry with at least a C and be concurrently enrolled in Algebra II, or have passed algebra II with at least a C. Continuing students must maintain at least a 2.0 GPA, 10 or fewer absences per semester, and have no discipline record. Ninth, tenth, and eleventh grade continuing students must maintain a C average in the TTC courses in order to continue in the pre-engineering program.

ACT Reading & Math Scores

Academic Points	Minimum	Maximum
0	1.00	13.00
5	14.00	14.00
9	15.00	15.00
12	16.00	16.00
15	17.00	36.00

ACT PLAN & Explore Reading and Math Percentile Rank

Academic Points	Minimum	Maximum
0	1.00	5.00
1	6.00	10.00
3	11.00	16.00
5	17.00	19.00
6	20.00	22.00
8	23.00	26.00
10	27.00	34.00
12	35.00	40.00
14	41.00	46.00
15	47.00	99.00

TABE-D Reading and Math Grade Levels

Academic Points	Minimum	Maximum
0	1.00	2.90
1	3.00	3.90
3	4.00	4.90
5	5.00	5.40
6	5.50	5.90
8	6.00	6.90
10	7.00	7.90
12	8.00	8.90
14	9.00	9.90
15	10.00	12.90

TerraNova Reading and Math Percentile Rank

Academic Points	Minimum	Maximum
0	1.00	2.90
1	3.00	3.90
3	4.00	4.90
5	5.00	5.40
6	5.50	5.90
8	6.00	6.90
10	7.00	7.90
12	8.00	8.90
14	9.00	9.90
15	10.00	12.90

Figure 4. Reading and math test academic point values for admissions application.

The admissions office evaluates all applications on a point scale, for a possible 100 points. Depending on the grade the student is entering, the evaluation is slightly different. One part of the application is evaluated the same regardless of the entering grade – the career-cluster-interest survey. Every completed survey receives 50 points regardless of the results.

Entering ninth and tenth grade students can earn up to 50 points for their academic work. Academic work refers to the most recently completed math course and the accompanying grade earned. Figure 5 displays the distribution of the awarded points.

Academic Points					
9^{th} Grade			**10^{th} Grade**		
Course	Grade	Points	Course	Grade	Points
Algebra II A: 50	A	50	Algebra II A: 50	A	50
Algebra II B: 45	B	45	Algebra II B: 45	B	45
Geometry A: 40	A	40	Geometry A: 40	A	40
Geometry B: 35	B	35	Geometry B: 35	B	35
Algebra I A: 30	A	30	Algebra A: 30	A	30
Algebra I B: 25	B	25	Algebra B: 25	B	25
Pre-Algebra A: 20	A	20			
Pre-Algebra B: 15	B	15			

Figure 5. Admissions academic point values for previous courses.

Entering ninth and tenth graders can also earn a bonus point for each semester of middle school engineering courses they earned at least a grade of C.

Entering eleventh and twelfth grade students earn 50 points from the career-cluster-interest survey, 20 points if the program tour is competed, and a possible 30 points for reading and math test scores. TTC does not award these students academic points, but rather the students have to meet the admission academic requirements described above. Figure 4 outlines the academic points associated with the reading and math test scores.

TTC ranks students and accepts the top 280 scoring applications of future sophomores and juniors that want to continue the program at the TTC campus. If the cut-off line lands between equal core values, random selection is used. For future juniors and seniors who want to begin the program at the TTC campus, TTC selects the top 40 scoring applications. Grades in previous mathematics courses, mathematics and reading test scores, application deadlines, and campus visits all play a vital role in determining a student's acceptance in the pre-engineering program.

Research Sample

Data for this study were solicited using a purposive sample, representative of only students who were considered a completer of one of the pathways of TTC's pre-engineering program. Utilizing criterion-based sampling, participants in this study were 2015-2016 students who completed one pathway of TTC's pre-engineering program at the TTC campus and did not continue enrollment into the 2016-2017 school year due to program changes, preference choice, or high school graduation. This encompassed 141 students.

Data Sources

Data for this study came from three sources: archival data, survey, and focus group interviews. The following sections describe each type of data collected in this study.

Archived Program Data

This study used a variety of archival program area data. Archival data included student's demographic information and high school, which came from their TCC applications (see Appendix B); transcripts from TTC included course grades for the classes they took at TTC, and students' home high schools. The researcher analyzed the transcripts for previous coursework and course grades.

Instruments

Survey. The survey for this study included three non-cognitive characteristics scales, demographics, and questions pertaining to experiences at TTC (see Appendix C). The following sections describe each part of the survey.

Short Grit Scale (Grit-S). In order to measure participants' "perseverance and passion for long-term goals" (Duckworth & Quinn, 2009, p. 166), this study utilized the Short Grit Scale. Duckworth and Quinn (2009) validated a shortened version of the original 12-item grit instrument. They subjected this 8-item instrument to a battery of studies and found the 8-item instrument to be a more efficient measure of grit. The shortened grit scale includes four items measuring consistency of interest (reverse scale) and four items measuring perseverance of effort, all eight items are measured on five point Likert scale from 1 = not at all like me, to 5 = very much like me. The final score is calculated by finding the mean of the eight items. The resulting score will range from 1, meaning not gritty, to 5, meaning very gritty.

Mathematics self-efficacy scale – Revised (MSES-R). This study used the MSES-R to assess participants' mathematics self-efficacy. Betz and Hackett (1983) developed the MSES-R to assess undergraduate college students' mathematics self-efficacy. The MSES-R has 52 items and 3 subscales that participants rate their confidence to: solve math problems, complete math tasks, and satisfactory completion of mathematics college courses and science college courses requiring mathematics knowledge (Pajares & Miller, 1995). Participants rated their confidence on a five point Likert scale from 1 = not confident at all, to 5 = very confident. Composite scores can range from 52 to 260 with the larger number representing a higher mathematics self-efficacy. Betz and Hackett (1983) reported coefficient alpha values of 0.92, 0.93, and 0.9 for the three subscales: problems, courses, and tasks, respectively.

Implicit Theory of Intelligence Scale. Mindset was measured using the Implicit Theory of Intelligence Scale that includes three Likert type questions that participants rank their degree of agreeableness on a scale from 1 to 6, 1 = strongly disagree and 6 = strongly agree. The questions come from the prospective of a fixed mindset. A final mindset score is the mean of the three questions. Participants with scores less than or equal to 3 are considered to have a fixed mindset while participants with scores greater than or equal to 4 are considered to have a growth mindset. Participants with scores between 3 and 4 do not appear to have a definite mindset. Multiple researchers reported these items with internal reliabilities between .78 and .98 and test-retest reliabilities ranging from .77 to .80 (Blackwell, Trzesniewski, & Dweck, 2007; Dweck, Chiu, & Hong, 1995).

TTC Specific Questions. In order to collect additional data about students that completed one of the three pre-engineering pathways at TTC, TTC specific questions were included to describe their expectations and experiences. Open-ended questions were included on the survey to assess students' personal perceptions and reflections of TTC's pre-engineering program. The questions began with their reason why they chose to attend the pre-engineering program, followed by what their expectations were for the program. The questions progressed through the experiences at TTC with what was helpful and/or not helpful to completing one of the pre-engineering pathways.

In one particular question, participants were asked to rate how helpful specific items were to completing their pre-engineering pathway. The researcher selected these items from John Hattie's book, *Visible Learning* (2009) as the most applicable to the participants –

- prior achievement,
- class size,
- ability grouping,
- decreasing disruptive behavior,
- peer influence,
- quality of teaching, and
- teacher-student relationships,
- inquiry-based teaching,
- direct instructions
- problem-based learning, and
- cooperative-based learning.

Hattie measures the learning effectiveness of these educational influences on his barometer of influence. Through a meta-analysis, Hattie averages the effect sizes of education influences. If an educational influence receives a rating greater than or equal to 0.4, Hattie concluded that influence had a positive influence on student achievement outcomes. In this study, participants will rate the degree each educational influence had on their success at TTC on a 5-point Likert-type scale where 1 = not helpful and 5 = very helpful.

Interviews and Focus Group Interviews

The researcher conducted interviews and a focus group interview to collect and triangulate data, as well as deepen the responses from the survey. The interviews and focus group interview used a semi-structured interview protocol (Corbin & Strauss, 2015) (see Appendix D). The nature of semi-structured interviews allows possible probes to provide more depth and meaning to the participants' responses (Patton, 2002). The questions remained focused and did not suggest any particular response was to be expected but would potentially expand on the survey and archival data already collected.

Interview and focus group participants were chosen based on their responses to the survey regarding availability. If more than one participant was simultaneously available, a focus group interview was scheduled – otherwise an interview was scheduled. The researcher conducted one focus group interview and four individual interviews during this study. Both types of interviews lasted approximately 20 minutes.

Data Collection Procedures

This study utilized both quantitative and qualitative data sources. The archival data from TTC and the survey provided quantitative data. The application, survey, and focus group interviews provided qualitative data. Prior to data collection, the researcher provided participants with an informed consent via the first question on the online survey. The informed consent page included the purpose of the research, general information collected, security of responses, and risks and benefits of participation.

There were two phases of data collection. During the Fall & Winter of 2016, the researcher emailed the survey out to all participants. The researcher emailed two reminders to the participants, each one week apart from the other. Once surveys were completed (17% response rate), they were analyzed and reviewed for possible focus group or interview attendees. Interviews and focus group interviews were the second phase of the data collection for this study. The researcher conducted four individual interviews and one focus group with two participants.

Data Analysis

The researcher used IBM SPSS software package, Version 23 to analyze quantitative data. The statistical tests provided descriptive statistics (e.g. means, standard deviations, etc.), inferential statistics (e.g. sign goodness of fit tests), descriptive analysis, and one-way ANOVA. These statistics provided data to describe the participants.

The researcher transcribed all qualitative data for storage and analysis. Patton (2002) presented a systematic approach to analyzing qualitative data. The first phase of qualitative data analysis consisted of the researcher reading the data multiple times while making comments of organizational ideas. After a thorough reading, the researcher employed the constant comparative method. The purpose of the constant comparative method is to discover all possible aspects of a phenomenon (Corbin & Strauss, 2015). The constant comparative method is the act of taking data and comparing it to all other data. Depending on similarities and differences, the researcher grouped data together. As the researcher distinguished more data by grouping, categories or labels emerged to describe the essence of the phenomenon (Corbin & Strauss, 2015).

During this research study, the researcher analyzed all qualitative data related to the first research question regarding the participants' reason for attending the pre-engineering program and their expectation of the program separately for codes. After the researcher identified all codes from the data, the researcher condensed the codes into themes that described the participants' reactions. The researcher conducted a similar process for the data concerning the final research question regarding the items participants identified as helpful to completing the program.

Table 1 provides a summary of the research questions, data sources, and the data analysis procedure for each research question.

Table 1

Research Overview

Research Question	Data Sources	Data Analysis
1. What are the factors that influence student's TTC pre-engineering program enrollment?	• Archival Data • Survey • Focus group interviews	• Constant-comparative method
2. What are the personal, cognitive, and non-cognitive characteristics of students who completed one of three pathways of the TTC pre-engineering program?	• Archival data • Survey	• Constant-comparative method • Descriptive statistics • Inferential statistics • ANOVA
3. What are the differences in student characteristics between the three different pathways of completion of the TTC pre-engineering program?	• Archival Data • Survey	• Discriminant analysis
4. What do TTC pre-engineering program students identify as beneficial and/or not beneficial to participating in the program?	• Survey • Focus group interviews	• Constant-comparative method

Trustworthiness

Trustworthiness in this study encompassed credibility, dependability, and transferability. Although the researcher was a current instructor for TTC and was possibly a past instructor to some of the participants, the researcher bracketed any biases and subjective perspectives during the study. The researcher triangulated data collected to ensure valid research conclusions. The researcher invited participants to review the study's findings to ensure the researcher's summaries and inferences translated accurately. The researcher ensured dependability with detailed data collection and data analysis documentation. Descriptions of participants and setting were enriched with detail in order for other researcher to determine this study's transferability (Bloomberg & Volpe, 2012; Patton, 2002). With credibility, dependability, and transferability accounted for, the research hopes to convey trustworthiness to the readers

Ethical Considerations

The researcher applied and received permission from Oklahoma State University Institutional Review Board to conduct this study (IRB# ED-16-173), as shown in Appendix E. All research participants signed and agreed to be part of this study and were aware of any risks and benefits and the confidentiality protocols the researcher took. Data collected from the survey were not anonymous; however, the researcher reported no names or identifying information. Names were necessary in order to align the archival data with the data collected from the survey. The survey also identified which of the participants were willing to be part of the focus group. After the researcher formed and confirmed interviews and a focus group, a unique numbering system replaced all names in the data in order to protect their identity, privacy, and confidentiality.

Summary

This mixed methods study aimed to describe the students and their experiences at TTC's pre-engineering program. Applications, surveys, and focus group interviews provided the data for the researcher to analyze and draw conclusions. This chapter summarized the research design, setting, participants, data sources, procedures, and analysis. Chapter IV contains the results of the data analysis and a discussion of the results follows in Chapter V.

CHAPTER IV

RESULTS

This mixed methods research study combined both qualitative and quantitative data to examine the personal, cognitive, and non-cognitive characteristics of students that completed one of the three pre-engineering pathways at TTC. The specific research questions guiding this study were:

1. What are the factors that influence students' TTC pre-engineering program enrollment?
2. What are the personal, cognitive, and non-cognitive characteristics of students who completed one of three pathways of the TTC pre-engineering program?
3. What are the differences in student characteristics between the three different pathways of completion of the TTC pre-engineering program?
4. What do TTC pre-engineering program students identify as beneficial and/or not beneficial to participating in the program?

This chapter will present the findings from the research including archival, survey, and interview data. First, results from the archival data will describe the 141 participants and the survey results will describe the 24 participants who completed the survey. Second, data will be compared between participants depending on their completing pathway – foundations of pre-engineering, pre-engineering, or advanced pre-engineering.

Factors Influencing Enrollment

In order to determine the factors that influence enrollment into TTC's pre-engineering program, participants were asked to respond to two open-ended questions in the survey and focus group interviews about their experiences pertaining to the TTC pre-engineering program. Responses were analyzed for categories and themes using the constant comparative method (Corbin & Strauss, 2015).

The analysis of the responses to "Why did you chose to apply for TTC's Pre-Engineering program?" revealed four major codes. The first code was the nature of the courses the program offered. Participants indicated that they enrolled in the pre-engineering program because they wanted to take courses that were more rigorous, diverse, and advanced than the courses offered at their high school. For example, one participant stated "to take more challenging courses" while another stated, "in order to learn higher-level mathematics." One other participant responded, "It seemed more useful than traditional, non-STEM focused classes." All responses within this code suggested that students felt the pre-engineering program would provide them with richer, deeper, and more interesting courses than the courses offered at their high school.

The second code was the interest in engineering. In addition to courses offered within the pre-engineering program, participants also specified that the program offered them a chance to feed their interest of engineering and explore more about engineering as a potential future career. Responses included "seeing if engineering was something I could do with my life" and "engineering sounded like a great career to look into." One respondent went on to say, "I wanted to expand my knowledge of engineering and determine if that would be a degree I would like to pursue." Responses within this code suggest that students participate in the pre-engineering program to aid their future career decisions related to engineering.

Two smaller codes emerged while analyzing the responses to this question; the first was the goal of becoming an engineer. Some participants seemed confident in their career choice of being an engineer by saying, "I want to become a mechanical engineer" and "I knew I wanted to go to an engineering college to study engineering." This code included students who had previously determined their career goals of engineering; some even had decided what type of engineering they wanted to study.

The final code that came from the survey responses was college preparation. Some responses were general about further education such as "I thought it would prepare me for college" and "I believed that it would be a good head start and look good on college applications." These responses indicated that students enrolled in the pre-engineering program in order to prepare for their post-secondary education.

During the interviews and focus group interview, participants were again asked, "What initially interested you in applying to the pre-engineering program?" Six codes emerged from the analysis of focus group transcripts. The most prominent code was exploring engineering. Students indicated that their eagerness to learn more about the career of engineering drove them to enroll in the program. Responses such as "I wanted to see if engineering was something I wanted to do" and "I thought that I might want to be an engineer but I wasn't sure." Responses within this code suggest that students wanted to enroll in the pre-engineering program in order to explore what a career in engineering might entail and if it was of interest to them. Participants thought of the pre-engineering program as a decision-making tool to inform themselves about engineering.

The nature and interest in the program's courses was the second code that emerged. Most participants referred to the initial presentation at their high school about TTC. TTC representatives give periodic presentations at the local high schools. The high schools also have a career advisor on campus to help educate students on what TTC has to offer. Responses included "I like what she explained about that you get to work on different things," "I remember sitting in a class watching a [presentation] and listening to some of the stuff I could do," and "it sounded like a lot of fun." This code was comprised of responses directly related to the activities and content of the courses offered within the pre-engineering program. The marketing from TTC encourages and enlightened students to join the pre-engineering program.

A third code identified as friends and family as an influence for enrollment. Participants mentioned a friend or family member that has some connections to either TTC or the pre-engineering program in particular. Replies within this code included "A few good friends were in there and [said] this is a really cool class" and "my mom went to TTC, too, for computer science; she was in favor of me going to TTC." Another participant said that he/she enrolled in the program because an older sibling had a good experience in the program. Whether in the pre-engineering program or in another program at TTC, friends and family seems to be influence students' enrollment.

The fourth code that arose was the fact that the engineering courses counted or substituted as high school credit required for graduation. One interviewee said, "A bonus was that I didn't have to do two years of foreign language" and another said that, "[IED] is also considered a computer class." Students seemed to like the fact that they could use the pre-engineering courses as some of their high school credit requirement for graduation and this could have been a determining factor for their enrollment in the program. As one participant put it, "if I wasn't able to take a math and science [credit course] I probably wouldn't be able to do it." Being able to double the pre-engineering courses as a high school credit that is required for graduation attracts many students to the pre-engineering program.

Achievement in previous courses was the fifth code. Participants said that their interest in the pre-engineering program was because of their previous achievement in mathematics and science courses. One participant said, "I made good grades in math and science" and another said, "I have the grades and went with it." It is important to remember that in order to enroll in the TTC pre-engineering program, some academic criteria had to be met, including minimum course grades and mathematics and reading test scores, but it seems that being successful in these courses/tests is also an encouragement to enroll in the pre-engineering program.

The final code that came from the focus group interviews was beginning the pre-engineering program in ninth or tenth grade. The participants had started the engineering course at their high school within their normal high school schedule and continued the program at the STEM Academy. There are seven high schools in the Tulsa area that offers the first two courses of the pre-engineering program – Introduction to Engineering Design and Principles of Engineering – the two courses required to complete the Foundations of Pre-Engineering pathway. Students can take one course their freshman year and one their sophomore year. Considering all of the participants in this study, 78% began the pre-engineering program at their high school. Taking the course at their high school seems to be a key factor in coming to the TTC pre-engineering program that is at the STEM Academy.

Since expectations for a program can be considered a factor leading to enrollment, the question "Describe what your expectations were for the program" responses were also analyzed for this research question. Three codes emerged from the analysis of survey responses. The first code seemed to be the most prominent and obvious – to learn more about engineering and to help make future career decisions. Some participants were more descriptive in stating that they "hope to learn basic engineering principles from different fields," "to learn more about the engineering process," and "to get experience with things I'd use in a career." In general, the responses to this question centered on learning more about engineering as a potential future career.

The second code that arose pertained to the nature of the courses in the pre-engineering program. Some participants indicated that they looked forward to being challenged in rigorous and advanced courses. One participant responded, "I expected it to be a fun yet challenging experience where I would be surrounded by intelligent teachers and challenged to think like an engineer." The focus of this code was centered around understanding participants who wanted to take more rigorous and interesting courses; which were not offered at their high school.

Participants also indicated that they were interested in the hands-on and real-life applications the courses offer. Participants said they expected "to learn math and how to apply it to real-life problems and form solutions," "a higher caliber of classes than my home high school that would focus on the application of knowledge," and "to be able to design objects and to actually being them to life." It seems that these participants wanted to not only learn math and science, but also explore how to apply it in real applications in the classroom.

In addition to the survey and interview data, some archival data gave some insights to possible factors that could have contributed to participants' enrollment in the pre-engineering program. Upon applying to the program, participants completed interest inventory surveys. The data showed that 40% of the interest inventories listed STEM as their highest scoring box. After STEM, 25% showed interest in information technology and nearly 19% had interest in architecture and construction. All of these career clusters have some form of engineering involved that could have been of interest to the participants and thus their enrollment in the pre-engineering program.

Collectively, this data paints a picture of the different items that attracted students to the pre-engineering program. The codes identified from the data sources can be collapsed into four over-arching themes. The first theme is the nature of the pre-engineering program's courses. The courses offered by the pre-engineering courses entice students by providing a challenging and contextual learning experience. The students specifically mentioned their desire to take the rigorous courses offered. Participants enjoyed the challenge of the courses and the learning that took place. Participants also mentioned the hands-on aspect of the courses. These courses offer students the opportunity to construct knowledge by applying learned skills to class assignments and projects. The marketing of the courses by TTC representatives and career advisors showed students the collaborative, contextual teaching and learning that takes place in the courses. These participants sought out the ore-engineering program for its fun, engaging, and challenging courses.

The second theme related to the engineering aspect the pre-engineering program offered. Participants enrolled in the pre-engineering program because they were interested in learning more about what engineering entails. Exploring engineering included looking deeper into the different engineering fields and learning some engineering principles. Participants indicated that they enrolled in the pre-engineering program because of their strong engineering focus that the coursework and activities of the program emphasized. Students wanted to be immersed into an engineering-focused school environment to inform themselves about engineering and as an aid to make future career and educational decisions.

Self-awareness of academic achievement also influenced students' decisions to attend the pre-engineering program on the TTC campus. Students with high academic achievement in their previous coursework, especially in math and science courses, found that they qualified to enroll in the pre-engineering program and did so for that reason. Participants who also enjoyed their previous math and science courses were attracted to the pre-engineering program due to the program. Students also had their future academic goals in mind when enrolling in the pre-engineering program. Some students had pinpointed that they wanted to become and engineer and sought out this program in order to help them achieve this goal. Other students had other college goals in mind and wanted to attend the pre-engineering program to help prepare them for college curriculum. Most of the participants in this study began the pre-engineering program at their high school. There students had to achieve a grade of C or better to continue to the TTC campus for the remaining pre-engineering courses. This early exposure to the pre-engineering curriculum and academic success influenced many participants' decision to continue in the pre-engineering program. Academic achievement, both past and present, influenced participants' decision to enroll and attend the TTC on campus pre-engineering program.

The final theme that encapsulates the codes found in the data is word of mouth from participants' peers and family. Peers and classmates influenced some participants into beginning the pre-engineering program. These peers and classmates coerced their fellow peers and classmates into enrolling in the pre-engineering program by sharing their experience in the program or from what they had learned about the program. Siblings also played a role in students enrolling in the pre-engineering program. Some participants had older siblings that had completed the pre-engineering program previously and apparently had a good experience. Parents who had previously attended TTC also influenced participants' enrollment. Although the parent did not attend the pre-engineering program, they had a positive experience at TTC and felt that the pre-engineering program would be a good experience for their son or daughter. The influences of those peers and family surrounding a student influenced students' enrollment into the pre-engineering program.

In conclusion, four major sources influenced students' decision to enroll in TTC's on campus pre-engineering program: the nature of the courses, the engineering-focused environment, self-awareness of academic achievement, and word-of-mouth. Some participants identified one of these factors as enrollment influencers and other participants identified more than one of these factors. These factors play a major role in students' decision to enroll in the on campus TTC pre-engineering program. The students that enroll in the pre-engineering program ultimately come for their own interests and academic and career goals. Most of all, the participants showed that they are enrolling in the pre-engineering program to learn more and to explore engineering, which is an important goal of the program.

Characteristics of Participants

In order to describe the personal, cognitive, and non-cognitive characteristics of the participants, quantitative data were collected in two ways: archival and survey data. The archival data analyzed in this study came from the participants' TTC applications and transcripts on file. The information from the applications was personal, and included gender, ethnicity, and high school. Cognitive data were collected from the transcripts, namely course grades. Survey data analyzed was comprised of the non-cognitive data including the MSES, mindset, and grit scores.

First, participants' gender was analyzed. Participants in this study were comprised of 117 (83%) males and 24 (17%) females. With this overwhelmingly male population, a sign test was conducted to compare the difference in the size of the two groups. This test showed that the size of the male group is significantly larger than the size of the female group, $z = -7.748$, $p < 0.001$. Males seem to make up the majority of the students that attended the pre-engineering program.

The ethnicities of the participants were analyzed and compared to the state average ethnic distribution. The ethnic distribution was also compared to the ethnic distribution of five of the sending high schools (76% of participants come from these five high schools). Table 2 shows these figures. First, the ethnic make-up of the participants at TTC was mostly white students (74%) with Hispanics making up the next largest ethnic group (10%). This white population percentage, as compared to the other non-white ethnicities, is a significantly larger group, $z = -5.727$, $p < .001$. Compared to the other schools and state average, TTC seems to have more white students than the state average and more than four out of the five schools included. The percentages of Asian, Black, and Hispanic students at TTC seem to be near the percentages of the other schools and the state average. On the other hand, TTC participants had a lower percentage of Alaskan Native/ American Indian students.

Table 2

Ethnicity Distributions by School District

	TTC	School District 1	School District 2	School District 3	School District 4	School District 5	OK State Average[a]
Alaskan Native /American Indian	5%	7%	6%	7%	8%	15%	14%
Asian	3%	10%	7%	3%	1%	3%	2%
Black	8%	7%	15%	6%	2%	5%	9%
Hispanic	10%	13%	25%	11%	8%	9%	16%
White	74%	62%	46%	73%	81%	68%	58%
χ^2		15	20	20	15	20	20
p		0.241	0.220	0.220	0.241	0.220	0.220

[a] (Oklahoma State Department of Education, 2016)

A chi-square goodness of fit test was conducted to determine whether the participants within the study had the same ethnicity proportions as those in the local high schools. The test indicated that the distribution of the five ethnicities were not similar to the participants' ethnic distribution. This means that students that attend the pre-engineering program are leaving their high school and attending a school that has a significantly different ethnic distribution. A visual inspection of the data suggests that three of the schools had a more diverse student population while TTC had a predominately white population, namely school districts one, two, and five.

Another consideration is the type of school these participants come from. Oklahoma categorizes schools into different communities depending on the size of the district and the socioeconomics of the enrolled students. Letters A-F indicates the size of the district. Table 3 defines each letter's population range. The socioeconomics value is either one or two. One indicates that the percentage of students who qualify for free and reduced lunches (FRL) was at or below the state average. A label of two indicates that the number of qualifying FRL students is above the state average (Oklahoma State Department of Education, 2015). If Tulsa Technology Center was classified into these categories, it would be a D2 community. This means that most students coming to the pre-engineering program are coming to a smaller district than their high school.

Table 3

Community Classifications

	A2	B1	B2	C1	D1	F2
Percentage of Participants	10.6%	11.3%	11.3%	26.20%	6.4%	0.7%
District Population	25,000+	10,000-24,999	10,000-24,999	5,000-9,999	2,000-4,999	500-999

Cognitive characteristics refer to characteristics that define an individual's level of knowledge. Cognitive data were collected to describe participants' academic success. Data included courses grades from TTC and high school transcripts. Please note that the descriptive statistics in the tables below are only indicative of the data on the transcripts held by TTC and the high school transcripts that TTC had in the participants' files. For example, one participant may have a grade for their Algebra I and Geometry course while the next participant only had a Calculus grade listed. The Algebra I and Chemistry grade point averages (GPA) are included in order to make comparisons to past studies. These course GPAs were calculated by taking the mean of the two semesters comprising that course. The math and science GPAs were calculated by taking the mean of all semesters of math and science available. The core GPA was calculated by taking the mean of all math, science, language/literature, and social studies course grades available. Table 4 shows the data collected from archival data.

Table 4

Mean Grade Point Averages (GPA) by Subject

	Overall		Foundations Pathway		Pre-Engineering Pathway		Advance Pre-Engineering Pathway	
Subject	*n*	M (SD)	*n*	M (SD)	*n*	M (SD)	*n*	M (SD)
Algebra 1	113	3.35 (0.67)	43	3.28 (0.73)	41	3.29 (0.65)	29	3.53 (0.54)
Chemistry	93	3.40 (0.70)	31	3.31 (0.68)	38	3.25 (0.76)	25	3.56 (0.59)
Math	139	3.23 (0.70)	47	3.12 (0.76)	51	3.29 (0.66)	41	3.34 (0.64)
Science	129	3.30 (0.73)	46	3.13 (0.86)	48	3.38 (0.57)	35	3.46 (0.69)
Core	141	3.28 (0.72)	49	3.12 (0.85)	51	3.35 (0.61)	41	3.38 (0.64)

Overall, students that completed a pathway of the pre-engineering program tend to make A's and B's in most classes. These students' core GPA falls in line with their math and science GPA, indicating that in the other core courses they are earning similar grades, not just in math and science. The students that completed the foundations pathway seemed to be equally strong or stronger in math and science courses than their other subjects. The pre-engineering pathway completers seem to have similar GPAs, science being the highest of the GPAs calculated. The completers of the advanced pre-engineering pathway have the highest GPAs of all three pathways.

Non-cognitive characteristics refer to an individual's characteristics that not related to knowledge or experience but rather feelings and intuition. Non-cognitive characteristics of participants were collected via online survey. Twenty-four participants completed the survey. Measures on the survey included the Mathematics Self-Efficacy Scale (MSES), Grit, and Theory of Intelligence (Mindset). Table 5 shows the description of the survey data.

Table 5

Descriptions of Survey Data

Measure (possible scores)	Overall (n = 24)	Foundations Pathway n = 5	Pre-Engineering Pathway n = 13	Advance Pre-Engineering Pathway n = 6
	M (SD)	M (SD)	M (SD)	M (SD)
MSES grand total (52-260)[a]	219.17 (24.54)	226 (24.09)	218.38 (20.81)	215.17 (30.44)
Mathematical Tasks (18 – 90)	76.63 (9.35)	69.80 (11.78)	77.46 (7.86)	80.50 (7.30)
Problem Solving (18 – 90)	80.08 (10.89)	79.20 (6.10)	78.92 (13.02)	83.33 (6.94)
Course Completion (16 – 80)	62.46 (10.27)	57.00 (12.19)	64.08 (10.23)	63.50 (6.83)
Grit (1-5)	3.35 (0.43)	3.33 (0.56)	3.46 (0.30)	3.15 (0.48)
Mindset (1-6)	2.31 (1.45)	1.07 (0.15)	2.82 (1.60)	2.22 (0.83)

[a]The sum of the three MSES subscales

A one-way ANOVA was conducted to determine if the MSES grand total score or any of the three subscales were different for groups in the different pathways. The participants were grouped by pathway: foundations (n = 5), pre-engineering (n = 13), and advanced pre-engineering (n = 6), There was homogeneity of variances, as assessed by

Levene's test of homogeneity of variances (p = 0.404). The MSES scores increased from advanced pre-engineering (M = 215.167, SD = 33.343), to pre-engineering (M = 218.385, SD = 21.662), to foundations (M = 226, SD = 24.094) pathways, in that order, but the differences between these pre-engineering pathways was not statistically significant. This increasing pattern from the advanced pathway to the foundations pathway is in contrast to what might be predicted. As shown, as the pathway increases in the number of courses required, the MSES scores decrease, although the differences were not significant.

The MSES subscales were also analyzed using a one-way ANOVA to find any significant differences between the three pathways of completion. in the first subscale, mathematical completion, participants rated their confidence in completing the listed mathematical tasks. The score for mathematical tasks increases from the foundations pathway (M = 69.80m SD = 11.78) to the pre-engineering pathway (M = 77.46 SD = 7.86) and increases again to the advanced pre-engineering pathway (M = 80.50, SD = 7.30). The participants' rating of their abilities to solve mathematical problems decreased from the foundations pathway (M = 79.20, SD = 6.10) to the pre-engineering pathway (M = 78.92, SD = 13.02) and then increased from the pre-engineering pathway to the advanced pre-engineering pathway (M = 83.33, SD = 6.94). Finally, the participants rated their ability to successfully complete the listed math and science courses. These scores increased from the foundations pathway (M = 57, SD = 10.27) to the pre-engineering pathway (M = 78.92, 13.02) and decreased from the pre-engineering pathway to the advanced pre-engineering pathway (M = 63.5, SD = 6.83). Although there are some small discrepancies and no statistically significant differences between the three pathways, the subscale score generally increased as the complexity of the pathway of completion increased. This increasing score could be predicted as students progress through more math and science courses as the pathways increase in the number of required courses.

A one-way ANOVA was also conducted to determine if participants' level of grit was different for groups in the different pathways. There was homogeneity of variances (p = 0.328). The level of grit between the three pathways increased from the foundations pathway (M = 3.325, SD = 0.563) to the pre-engineering pathway (M = 3.462, SD = 0.312) and decreased from the pre-engineering pathway to the advanced pre-engineering pathway (M = 3.126, SD = 0.527) but these differences were not statistically significant. Grit is the level of tenacity or perseverance an individual possesses. One might predict that the students that persevered through the advanced pre-engineering pathway would have the higher level of grit. This data showed just the opposite: as the level of grit increased, the pathways decreased in the number of courses required.

For mindset, the homogeneity of variances was violated, as assessed by Levene's Test of Homogeneity of Variance (p = 0.003). Mindset scores increased from the foundations pathway (M = 1.067, SD = 0.149) to the pre-engineering pathway (M = 2.8215, SD = 1.665) but decreased from the pre-engineering pathway to the advanced pre-engineering pathway (M = 2.222, SD = 0.911). Since the test of homogeneity was violated, a Games-Howell post-hoc analysis revealed that the mean increase from foundations to pre-engineering pathway (1.754, 95% CI [0.516, 2.992]) was statistically significant (p = 0.007). According to Carol Dweck (2006), participants with mindset scores less than or equal to 3 are considered to have a fixed mindset and participants with scores greater than or equal to 4 are considered to have a growth mindset. Of the 24 participants that completed the survey, only five participants reported a growth mindset score, 18 reported a fixed mindset, and one participant had a score between three and four – indicating no definite mindset. So, although students who completed the pre-engineering pathway had significantly higher mindset score than completers of the foundations pathway, most of the participants' mindsets were fixed.

These personal, cognitive, and non-cognitive characteristics describe the participants in this study. Combining archival and survey data, these characteristics describe the completers of one of the pre-engineering pathways offered through the pre-engineering program. Gender, ethnicities, and grit levels showed to be the statistically significant differences. Next, an analysis of any differences across the three pathways was conducted.

This comparative analysis utilized both the archival data as well as the survey data. Participants were grouped according to their completion pathway – foundations of pre-engineering, pre-engineering, or advanced pre-engineering. These pathways are dependent on the number of pre-engineering courses completed while enrolled at TTC. As stated before, not all participants have the same courses on their transcripts; therefore, the *n* will differ in the analyses presented below.

Discriminant analysis was chosen for this analysis because of its ability to differentiate and predict whether there were differences in Algebra I, Chemistry, Math, Science, and core GPA, as well as MSES, grit, and mindset scores across the three pathways. Eight separate discriminate analyses were performed.

Table 6

Wilks' Lambda and Significance of Discriminate Analyses

	Wilks' Lambda	Chi-square	df	Sig.
Algebra I GPA	0.973	2.957	2	0.228
Chemistry GPA	0.98	1.838	2	0.399
Math GPA	0.985	2.033	2	0.362
Science GPA	0.974	3.251	2	0.197
Core GPA	0.977	3.205	2	0.201
MSES	0.976	0.518	2	0.772
Grit	0.902	2.161	2	0.339
Mindset	0.771	5.474	2	0.065

Each discriminate analysis suggested no significant differences between the eight variables between the three completion pathways. This is not surprising when one considers the mean values were so similar.

With all data sources considered, there were four key findings in the data analysis of participants' characteristics – a predominately white male population, students are coming from a high school larger than TTC and also high schools with different ethnic distributions, and the pre-engineering pathway participants had a significantly higher mindset score than the foundations pathway completers. These are the most distinguishing characteristics found within the scope of this research study.

Factors for Success

Thus far, this study explored the reasons why students enroll in the pre-engineering program and the characteristics of these students. The final research question set out to explore what the participants deemed as helpful while completing their pre-engineering program. The data sources informing this question were the open-ended questions in the survey, the interviews, and the focus group interview. Data were analyzed for codes using the constant comparative method (Corbin & Strauss, 2015). Three codes emerged from the analysis of the survey data from the question "Describe what the TTC pre-engineering program provided that you deem helpful for your success at the STEM academy." The most noticeable code was the exploration of different types of engineering. Responses included "they provided me with a closer look as engineering majors," "the program emphasized thinking like an engineer," and "a more specific look at what a degree in engineering may look like." Responses within this code were focused on learning more about engineering and engineering careers.

Another code was the quality of instructors at TTC's pre-engineering program. Participants praised the teaching staff by saying things like "teachers were very supportive" and "endless support from the teachers." This data shows that the students have a like and respect for their instructors. Having that relationship and respect could be one factor that helps lead students to complete the pre-engineering program.

The final code centered on the learning environment. The environment was described as "positive," "promoted teamwork," and an "atmosphere of like-minded individuals." Responses within this code showed that the participants enjoyed the environment that the pre-engineering program provided. Students wanted to come into a classroom where they are respected, encourages, and collaborative and the pre-engineering program offered such a learning environment.

The participants were also asked to "Describe what the TTC pre-engineering program provided that you deem not helpful for your success at the STEM academy?" Most of the responses participants left were "nothing" or "none," although a few students mentioned the lack of college-credit bearing courses and the limited engineering fields available to explore.

Questions from the survey also asked participants to rate a selection of factors that John Hattie (2009) identified as having an impact on students' academic success. Participants rated each factor on a scale from 1 to 5 where 1 was not helpful and 5 was very helpful. Table 7 shows the breakdown of each factor. Most of the factors listed were rated as helpful to the participants' success.

Table 7

Influencing factors on a 1-5 scale

Factor	M (SD)
Your achievement in prior courses	4.46 (0.66)
The class sizes	4.38 (0.65)
The students	4.29 (0.86)
The decrease in disruptive behavior	4.75 (0.53)
Your peers	4.46 (0.66)
The quality of teaching	4.83 (0.48)
The teacher-student relationships	4.83 (0.38)
The use of inquiry-based teaching (learning through exploration)	4.67 (0.64)
The use of direct instruction	4.63 (0.58)
The use of problem-based teaching (learning in order to solve a problem)	4.75 (0.53)
The use of cooperative learning	4.46 (0.66)

Of the factors included in the survey, participants ranked each of them as helpful. Students rated the quality of teaching and the student-teacher relationships as the most helpful towards the successful completion of one of the pathways. This is a repeated result from the open-ended survey and focus group interview questions about what help them succeed. Least helpful, but still in the helpful range was the class sizes. Although the pre-engineering courses typically have less than 20 students in a classroom, based on that the survey and focus group interview indicated, the participants in this study did not think that had an effect on their successful completion of the pre-engineering program.

From this data analysis, two themes formed. First, the participants in this study identified the fact that the pre-engineering program provided them with a broad overview of what engineering in a contextual learning environment as a key factor in their successful completion of the pre-engineering program. The students identified earlier that learning more about engineering was one reason they enrolled in the pre-engineering program. The program provided what was promised to the students in the descriptions and reputation of the pre-engineering program.

Second, participants identified the instructors of the pre-engineering program as a key factor to their success. Participants described the teaching staff as knowledgeable in their subject areas and were able to convey the information to students in a way that promoted contextual learning and relayed information in a productive manner. The support from the instructors was also mentioned as a factor in students' success. The participants thought the faculty was respectful, encouraging, and supportive of their students. The students-teacher relationships played a role in students successfully completing one of the three pathways of completion. In total, these two themes encompass the benefits identified by the participants in this study.

Summary

This chapter presented the data collected from archival, survey, and focus group interviews. Analyses of this data were computed and examined for significance, codes, and themes. This data represented the participants as a whole and as groups depending on their program pathway completed. The next chapter will provide a summary of these results as well as discuss conclusions, implications, and recommendations for future research.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The number of STEM career vacancies and opportunities is increasing across the nation (ACTE, 2009). STEM career fields ranging from national security to aerospace engineering need more advanced, educated, and STEM literate individuals to fill these positions (AIA, 2008; Marshall, Coffey, Saalfeld, & Colwell, 2004). In contrast, the number of college students attaining STEM related degrees has been decreasing since 1985 (Freeman, 2006).

In an effort to interest students in a STEM degree field, schools are putting a heavier focus on STEM explorations in an effort to interest students to pursue a STEM degree and hopefully a STEM career (Hirsch, Kimmel, Rockland, & Bloom, 2005). This study looked at one pre-engineering program offered to high school students. Specifically, this study looked at the factors contributing to students' enrollment and success and the characteristics of students who attended the pre-engineering program and completed one of the three pathways offered - foundations of engineering, pre-engineering, and advanced engineering. The questions guiding this study were:

1. What are the factors that influence students' TTC pre-engineering program enrollment?
2. What are the personal, cognitive, and non-cognitive characteristics of students who completed one of three pathways of the TTC pre-engineering program?
3. What are the differences in student characteristics between the three different pathways of completion of the TTC pre-engineering program?
4. What do TTC pre-engineering program students identify as beneficial and/or not beneficial to participating in the program?

This mixed methods research study utilized quantitative and qualitative data to describe the participants. Participants were students who had completed one of the three pathways during the 2015-2016 school year, which included 141 individuals. Archival data were collected from school records. Data were also collected from 24 participants that completed an online survey. Following the survey, two participants attended a focus group interview and four participants attended an interview with the researcher. Results from both the quantitative and qualitative data were analyzed in order to describe the students that complete a pathway of the pre-engineering program.

Factors Influencing Enrollment

This first research question sought to determine the factors that influence students' enrollment in the pre-engineering program. Qualitative and quantitative data were collected and analyzed. Responses to survey questions and focus group interview questions were examined and themes were determined from the data. The interest inventory from participants' enrollment application was also analyzed to help answer this research question.

Data revealed that participants enrolled in the pre-engineering program for the rigorous content and course objectives of the courses offered in the pre-engineering program. Students said that they liked the interesting, yet challenging nature of the coursework. Some students did not have some of the TTC courses at their high school and preferred to commute to the TTC campus just for those courses. Some participants preferred to be at a school that focused on more STEM related courses rather than the broad, non-STEM focused course selection from their regular high school.

Participants also enrolled in the pre-engineering program because of their interest in engineering. Since it is a pre-engineering program, it is not surprising that students enroll in the program specifically for the engineering courses. Participants indicated that they wanted to learn more about engineering to help them decide if that was a career path they should pursue. Having an opportunity to try out a degree area while in high school is very advantageous of students who are going to be attending college in the future. Students can determine or eliminate engineering as a potential major, saving time and money. Cole, High, and Weinland (2013) conducted a study on college students who had completed the PLTW pre-engineering program. They found that even though students completed the pre-engineering program, they did not necessarily enroll or graduate with an engineering degree.

Data also revealed that some students enrolled in the pre-engineering program because they had already made up their mind to become an engineer. Other students indicated that they enrolled in the program to be better prepared for college. This could be due to the nature of the courses – the focus on engineering – or the rigor of the courses being similar to what they thought college classes would be like. The Cole, High, and

Weinland (2013) study also replicated this result. They found that the pre-engineering program did have a positive impact on the engineering retention and graduation rates.

Occasionally, a participant mentioned how they came to know about TTC's pre-engineering program. TTC provided fliers and presentations that intrigued students to look into the pre-engineering program further. The presentations of the different pre-engineering courses was what interested participants to enroll in the program. The marketing on TTC's behalf seems to work for some students.

Some participants mentioned that they came to the pre-engineering program because of a close friend or family member. Some had older siblings or friends who attended the pre-engineering program and encouraged them to follow their example. Others had parents that attended or even taught at TTC and although they did not have a direct interaction with the pre-engineering program, their impression of TTC was great enough to encourage their children to attend one of their programs. The idea of familiarity and knowledge of availability of the pre-engineering program is an important factor in students' decision to enroll in the pre-engineering program. These influences are part of Bandura's social cognitive theory. Bandura suggested that behavior is determined by a triadic reciprocal system – personal, behavioral, and environmental factors. These peer and familial influences fall into what Bandura describes as the personal and environmental factors (Bandura, 1989).

Achievement and high school credit are also enrollment influencers. The data showed that students enrolled in the pre-engineering program because they excelled in their math and science courses. Although there are basic math and reading requirements to be accepted into TTC, the interest in math and science is a factor in their decision to enroll in the pre-engineering program. Students also liked that some of their math, science, and engineering courses counted as some of the required courses for high school graduation. Students take half of a day from their high school to come to the pre-engineering program. If they were not getting some of their credits required for graduation from the pre-engineering courses, many would probably not be able to afford the half day away from their high school.

The pre-engineering program offers the first two courses in all pathways – Introduction to Engineering Design and Principles of Engineering – at seven area high schools. The high schools integrated these classes into their scheduling and the students take them just as they would any other class at their high school, only the instructor is a TTC faculty member. This makes it easy for students to get a taste of the pre-engineering program while avoiding the schedule conflicts commuting to the on campus pre-engineering program may cause. A large percentage (78%) of participants in this study began the program by taking one or two of the foundations of pre-engineering courses at their high school. This early start in the pre-engineering program could be a determining factor in students' continuous enrollment to the pre-engineering program on campus.

As students fill out the application for the pre-engineering program, they also fill out an interest inventory that is intended to give career counselors an idea of where a student's interest may lie in respects of a future career path. The interest inventories of these participants were analyzed for their top scoring career cluster – the career cluster that they would ideally most enjoy. Almost 85% of the interest inventories submitted showed that students had an interest in fields within the STEM realm. This comes as no surprise given that these students were already filling out an application for the pre-engineering program.

Participants Characteristics and Differences

The second research question wanted to examine the personal, cognitive, and non-cognitive characteristics of the students that completed one of the pathways the pre-engineering program offers. Archival data were collected from the school records and an additional survey was collected from the participants who chose to complete the survey. The students who completed one of the three pathways were comprised of predominately male students (83%). A sign test showed that number of males in the program was significantly higher than the number of females. This almost comes as no surprise given there are some gender differences in the fields of mathematics and science. Freeman (2004) reported in secondary grades, females outperform males in reading and writing, but are generally lagging behind in mathematics and science. In post-secondary education, although females are more likely to complete a post-secondary program, males still dominate the number of degrees awarded in engineering. Freeman also reported that although the gender gaps in engineering are decreasing, they are still far from closed (Freeman, 2004).

Ethnicities of the pre-engineering students were examined and compared to other local high schools within the TTC school district. Over 75% of the pre-engineering students came from one of five high schools. In those five districts, a chi-square goodness of fit test showed that the ethnicities of the high schools are significantly different from the ethnicity proportions represented in the pre-engineering program. The ethnicity proportions from the pre-engineering program were also significantly different from the proportions of the Oklahoma state average. In all, students are attending an ethnically different school when they attend the pre-engineering academy; specifically they are attending one with a large white population and small Native American and Hispanic population.

The lack of ethnic diversity in the pre-engineering program is nothing new to the STEM fields. The National Science Board (2008) found that Asian Americans and white high school students are more likely to have taken advanced math and science courses that would prepare them for a STEM-focused post-secondary education. African Americans and Hispanics were the least likely to have taken these advanced STEM courses. Although these statistics show the ethnic gap in STEM courses, this gap is less than the gap in other course categories (National Science Board, 2008)

The size of the participants' high schools varied from 500 to over 25,000 students. About one-quarter of the students in the pre-engineering program came from a high school that had a population of 5,000 to 9,999 students. TTC had a student population of nearly 5,000 at the time these participants were at TTC (Tulsa Technology Center, 2017). This means that 59.4% of the pre-engineering students are attending a district that is quite smaller than their regular high school. Further, the pre-engineering program had a population of less than 500, which would be less than all of the high schools that are in the TTC school district (with exception of private and home schooled students).

Participants' grades from transcripts were collected, organized, and analyzed. Not all participants had grades for all courses, but all grades that were available to the researcher were analyzed. Overall, students carried A's and B's in most classes (core

GPA was 3.28). Grades were also classified in the pathway the participant completed. Students in the advanced pre-engineering pathway held the highest Algebra I GPA, 3.53, and the lowest standard deviation, 0.54. As the pre-engineering pathway decreases in number of courses required, so do the Algebra I GPAs, although the foundations pathway and pre-engineering pathway are extremely close, 3.28 and 3.29 respectively. Although this study did not find and significant completion predictor characteristics, Levi and Wyckoff (1990) found that Algebra I course grades were a predictor for students pre-enrolling in college as an engineering major.

Chemistry GPAs almost follow the same pattern as the Algebra I GPAs. Participants that completed the advanced pre-engineering pathway maintained the highest GPA and lowest standard deviation of the three pathways, 3.56 (0.59). Different from Algebra I, the foundations pathway completers' Chemistry GPA was greater than the pre-engineering pathway completers, 3.31 and 3.25. Levin and Wyckoff (1990) found that chemistry course grades were predictive of successful freshman year completion as an engineering major.

Math and science GPAs were calculated using all math and science course grades available. The math and science GPAs increase as the pathway level of completion increases. This could be because as the level of pathway completion increases, the students are taking more math and science courses. It could also be due to the course content of the pre-engineering courses that positively affects math and science course grades. LeBeau, et al. (2012) found high school math GPA to be a predictor value in the completion of a STEM degree. Core GPAs were calculated using all of the participant's math, science, language/literature, and social study courses available. Following the same pattern as math and science, the GPAs tend to increase with the increased length of the pathway, advanced pre-engineering pathway completers having the highest GPA, 3.38, and the foundations pathway completers having the lowest GPA, 3.12. Again, this could be due to the length the student has been in school and therefore the number of courses completed may be shortened. Levin & Wyckof (1990) identified a student's core GPA to be indicative of students pre-enrolling in college as an engineering major.

Although the current study did not find any significant predictors for completing the pre-engineering pathways, other researchers have found significant predictor towards a degree in the STEM fields. Levin and Wyckoff (1990) conducted a study that used high school characteristics to predict pre-enrollment in an undergraduate engineering program. They found that core GPA, Algebra I, gender, and Chemistry grades predicted students' pre-enrollment in an engineering degree program. LeBeau, et al. (2012) found that high school predictors such as gender and high school math GPA could be used to predict the completion of a STEM major. The current study did not find any significance regarding the prediction of the pre-engineering pathway completed via discriminant analysis.

Previous studies have found that academic self-efficacy had a strong, positive relationship and showed that academic self-efficacy as a significant predictor of academic success (Carroll, et al., 2008; Larson, et al., 2014). Carroll, et al. (2008) measured academic self-efficacy in 935 students from ages 11 to 18 and found that the students who hold themselves responsible for their learning and believe in their abilities to learn receive higher academic achievements than their less efficacious peers do. Larson, et al. (2014) studied the math and science self-efficacy of entering college students and found that this self-efficacy score could be used as a predictor of completing a college degree in four to eight years. More so, math and science self-efficacy were found to be a more accurate predictor of degree completion than measures of prior achievement or mathematics aptitude.

The present study utilized the Mathematics Self-Efficacy Scale - Revised (MSES-R) was used to determine the participants' level of math self-efficacy. This study found that as the pathway increases in courses required, the MSES-R scores decreased, although the differences were not significant. MSES-R was also not a significant predictor of pathway completion. Although both Carroll, et al. (2008) and Larson, et al. (2014) found academic self-efficacy to be a significant factor in academic achievement. This study found that MSES did not significantly factor into students' level of completion.

Participants' level of grit was measured to explore a connection between level grit and pathway completion. Although other studies (West, et al., 2016; Strayhorn, 2013) found that grit was a significant predictor in academic success, this study did not find grit as a significant factor in participants' level of completion. Grit has shown to be a key indicator of academic achievement, even more than traditional measure of academic ability.

This study found that participants' level of grit increased from the foundations pathway to the pre-engineering pathway, but decreased from the pre-engineering pathway to the advanced pre-engineering pathway. Although these differences were not significant, it is in line with the findings of West, et al., (2016) who found that students in charter schools that made large test score gains had reported lower levels of grit. TTC is similar to a charter school in that it requires application and acceptance and the participants in the advanced pre-engineering pathway had a lower level of grit, although it was not significantly lower.

The mindset scores in this study did show a significant difference between the foundations pathways and the pre-engineering pathway. The student that completed the pre-engineering pathway showed to have a higher mindset score than students in the foundations pathway. This is in line with previous studies that showed an increased mindset score tended to show greater academic success (Paunesku, et al., 2015; Blackwell, Trzesniewski, & Dweck, 2007). According to Blackwell, Trzesniewski, and Dweck (2007) and Dweck, Chiu, and Hong (1995) mindset scores less than or equal three are considered fixed mindset and scores greater than or equal to four are considered growth mindset. Score between three and four do not appear to have a definite mindset. This study's mindset scores were, on average, less than three. This means that the majorities of participants tend to have a more fixed in their mindset and are not confident in their abilities to learn.

Factors for Success

This final research question sought to find out what helped students succeed in completing one of the pathways in the pre-engineering program. Three themes emerged from the open-ended survey questions and focus group interviews. As presented earlier, students were attracted to the pre-engineering program for the opportunity to explore more about engineering in general and as a career. This was also one to the most common factors that students said helped them succeed. The students wanted to learn more about engineering came to the pre-engineering program and received what they had set out to gain. The interest in the course content was a factor in the students' successful completing of one of the pathways.

Many participants mentioned the quality of instructors they had at the pre-engineering program. Students said that the instructors were encouraging, positive, and knowledgeable. This is in line with Hattie (2009) and his meta-analysis on the quality of instruction. In his meta-analysis and averages of learning strategies' effects, Hattie found that the quality of teaching had an effect size of 0.44, which is considered to be above average in academic research. Students feel that having the quality teacher can have an impact on their success.

The classrooms provided students opportunities to collaborate with their peers on projects and assignments. The pre-engineering program provided these students with a learning environment conducive to learning. This is not in line with Hattie's research (2009). Hattie found that collaboration had an effect size of 0.29, which is still positive, but not as positive as other learning strategies. This difference in findings could be due to the nature of the courses in this study only pertaining to engineering while Hattie includes all grades and fields of study (Hattie, 2009).

Other factors from Hattie (2009) meta-analysis were measured on the participant's survey. The participants indicated that all of the factors listed were beneficial and helped them succeed in their pathway in the pre-engineering program. Hattie (2009) found that all of these strategies produce positive learning outcomes.

Implications

The findings of this study sought to advance the body of research related to high school pre-engineering programs. Engineering is a career field that is and will continue to be riddled with vacancies until there are enough well-qualified individuals to fill the vacancies (Task Force on the Future of American Innovation, 2005). Given engineering's rigorous content, many students begin but do not complete an engineering degree. The pre-engineering program examined in this study is one way of preparing students for the course content required to be achieved in college engineering degree programs. This study specifically explored who the students are that attend a high school pre-engineering program, why they attend, and what helps them to succeed. The aim of high school programs like this one is to encourage and prepare students to pursue degrees in engineering.

First, the findings indicate that students are drawn to the pre-engineering academy by their interest and curiosity about engineering. It is important that the course content and learning opportunities be expressed to potential students to encourage them to enroll in the program. Students in this study mentioned that they had sat through a presentation or saw a flyer with the pre-engineering program information. Students were also drawn to the rigor and challenge the pre-engineering courses offered. This shows that the high learning goals and the rigor of the pre-engineering courses are what students are craving. Teachers need to set the goals for their students high and encourage and nurture their thirst for learning. The effectiveness of a pre-engineering program can only be as great as the number of students that complete the program. Students have to be interested to come to the program in order to build the student population that potentially leads to an increased number of engineering degree holders.

Students also expressed their desires for a contextual teaching and learning environment. The hands-on aspect of the pre-engineering program and the PLTW curriculum structure a learning environment that is engaging and collaborative. Johnson (2002) concluded that more time students spend on challenging tasks that are interesting to them, require physical activity, and require higher order thinking, the more their brain will be stimulated. This study is evidence that students are yearning for this challenging contextual teaching and learning environment, much like what Dewey proposed as opposed to Prosser (Rojewski, 2002). This learning environment is important to the students and is important to the educators that students stay interested and engaged in learning.

Next, the characteristics of the participants in these students were examined. There was a noticeably large white male population in this pre-engineering program. This is a common trait of many engineering programs. The pre-engineering program in this study revealed similar gender and ethnic diversity as many engineering colleges and graduates (National Science Board, 2008). This shows that even before college, the gender and ethnic diversity is lacking and in need of more females and underrepresented minorities. In order to create a more diverse engineering field, the diversity of students interested in engineering will have to increase before college. This encouragement needs to start as early in schools as possible and at all schools. The more students that have to opportunity to engage in some kind of engineering, the more likely they are to pursue engineering as a career.

A possible solution to increase the number of females and underrepresented minorities could lie in an analysis of the entrance requirements. The academic requirements are set as such to maintain a certain level of rigor for the engineering courses, but this could keep may keep students from considering applying to attend the pre-engineering program. The entrance requirements the processes of communicating the requirements need to be re-evaluated to ensure all genders and ethnicities have an equal opportunity to enroll in the pre-engineering program.

Further, the TTC marketing team could re-evaluate their strategies to ensure they are inclusive of more females and under-represented minorities. If this large proportion of white males is evident in the off campus ninth and tenth grade programs at the high school, then the student recruitment strategies geared towards eighth grades need to be re-evaluated. However, if the off campus ninth and tenth grade programs are not lacking this diverse population, the on campus pre-engineering program recruitment strategies need to be re-evaluated. Either way, the marketing teams at TTC needs to remain aware of this primarily-white-male population at the on campus pre-engineering program and strategize methods of increase the gender or ethnic diversity to ensure that all genders and ethnicities have equal access to this pre-engineering program.

Within the non-cognitive characteristic analyzed, the mindset scores need to be addressed. As reported earlier, the majority of the students that completed the survey revealed a primarily fixed mindset. According to Dweck (2006), a person with a growth-mindset believes that a person’s basic qualities can change based on effort versus they are born with qualities and nothing can change those abilities, or a fixed mindset. People with a growth mindset believe it is impossible to see what can be accomplished, for them, anything is possible. In fact, people with a fixed-mindset may appear to be optimistic and intelligent, but it is when people are faced with difficulty or even failure that their mindset will show (Dweck, 2006).

As educators, we want students to believe that they can achieve their goals with hard work and perseverance. Individuals' mindsets can change throughout time and can be different depending on the present situations (Dweck, 2006). Paunesku et al. (2005) conducted a mindset training intervention in high schools across the U.S. The students who completed the mindset training showed an increase in academic achievement. This intervention could prove to be useful to the pre-engineering program's students. Chen (2009) found that less than half of students who declare a STEM major upon entering college actually graduate with a STEM degree. With a growth mindset, these students might persevere even more in attaining an engineering degree and thus increasing the number of qualified individuals to fill the ever-present STEM career vacancies.

Finally, students shared what they thought was helpful for success at the pre-engineering academy. As reported before, their interest in engineering kept them motivated. These students came to the STEM Academy to gain insights about engineering and engineering as a career. They were not let down as many of them said the course kept their interest and the program did what they expected it to do. Participants also praised the quality of teaching during the program. Programs that are leading to rigorous fields of study such as engineering need solid, educated, and trained teachers that know the material and know how to apply it to the classroom appropriately. Students also contributed success to the learning environment the pre-engineering program provided. The atmosphere of the STEM Academy afforded students the opportunity to collaborate and problem solve on projects and assignments, akin to real-world engineering. This gives students a realistic view of the nature of an engineering career and allows them to make better-informed decision about their educational futures. It is important that pre-engineering programs imitate real-world situations as often and as closely as possible.

As students are enjoying this engaging, engineering-focused, and collaborative environment, it would behoove TTC to present more stories of past students' positive experiences at TTC and where their future led. It is possible that if students enjoyed the environment the TTC pre-engineering program offered them, and they are able to see past students' path that TTC led them to, they, too, will strive to go further in education and careers. The lived experiences of previous TTC pre-engineering students could impact the current students in ways that no teacher or textbook could ever teach.

Future Research

The findings of this study suggest how to successfully encourage students to enroll in a pre-engineering program and how to help them succeed. Engineering is a predominately white male profession, even in this present study. More research is needed to explore why more minorities are not enrolling in pre-engineering programs.

The cognitive and non-cognitive characteristics were not significant in predicting the pathway students might complete within this pre-engineering program. This research could be widened to include students who do and do not complete a pre-engineering program. This research could lead to more indicators of students who are likely to succeed and can potentially be successful in completing an engineering degree. A longitudinal study could be conducted to track students who completed a pre-engineering program in high school and whether or not they attained an engineering degree.

Conclusion

In conclusion, this research makes important contributions to the area of pre-engineering education. The study revealed the interest that draws students into a pre-engineering program. This research also examined the characteristics of students that successfully completed a pre-engineering program. Lastly, this study revealed what students deem helpful to their success at the pre-engineering academy. This data could be used as a comparison to future studies that intend to find out what is necessary to prepare students for a career in engineering.

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APPENDICES

APPENDIX A

TTC's PLTW Course Descriptions

Aerospace Engineering (AE, 1 year)

This course propels students' learning in the fundamentals of atmospheric and space flight. As they explore the physics of flight, students bring the concepts to life by designing an airfoil, propulsion system, and rockets. They learn basic orbital mechanics using industry-standard software. They also explore robot systems through projects such as remotely operated vehicles.

Civil Engineering and Architecture (CEA, 1 year)

Students learn important aspects of building and site design and development. They apply math, science, and standard engineering practices to design both residential and commercial projects and document their work using 3D architecture design software.

Computer Integrated Manufacturing (CIM, 1 year)

Manufactured items are part of everyday life, yet most students have not been introduced to the high-tech, innovative nature of modern manufacturing. This course illuminates the opportunities related to understanding manufacturing. At the same time, it teaches students about manufacturing processes, product design, robotics, and automation. Students can earn a virtual manufacturing badge recognized by the National Manufacturing Badge system.

Computer Science Principles (CSP, 1 year)

Using Python® as a primary tool and incorporating multiple platforms and languages for computation, this course aims to develop computational thinking, generate excitement about career paths that utilize computing, and introduce professional tools that foster creativity and collaboration. While this course can be a student's first in computer science, students without prior computing experience are encouraged to start with Introduction to Computer Science. CSP helps students develop programming expertise and explore the workings of the Internet. Projects and problems include app development, visualization of data, cybersecurity, and simulation. The course curriculum is a College Board-approved implementation of AP CS Principles.

Digital Electronics (DE, 1 year)

From smart phones to appliances, digital circuits are all around us. This course provides a foundation for students who are interested in electrical engineering, electronics, or circuit design. Students study topics such as combinational and sequential logic and are exposed to circuit design tools used in industry, including logic gates, integrated circuits, and programmable logic devices.

Capstone Course - Engineering Design and Development (EDD, 1 year)

The knowledge and skills students acquire throughout PLTW Engineering come together in EDD as they identify an issue and then research, design, and test a solution, ultimately presenting their solution to a panel of engineers. Students apply the professional skills they have developed to document a design process to standards, completing EDD ready to take on any post-secondary program or career.

(PLTW, 2014)

APPENDIX B

TTC Application

Application

Contact Information

Legal First Name | Preferred First Name | Middle Name | Legal Last Name | Birth Date

Physical Mailing Address or PO Box (where you receive paper mail) | City | State | Zip Code

Email Address

Parent's Email Address

Home Phone | Work Phone | Mobile Phone | Other/Parent Phone

Program Information

Select...
When do you want to attend Tulsa Tech?

Select...
What grade will you be in when you want to attend Tulsa Tech?

Social Security Number

Required for adult applicants. You only have two attempts to enter your social security number correctly, so please type the numbers carefully.

Yes
Did you talk to a Career Advisor?

Select...
Career Advisor Name

High School Application Information

Yes
Are you home schooled?

Home School Association

Students who are home schooled must submit a notarized Home School Affidavit to the Admissions Office. A notary is available in the Admission Office. You may print the Home School Affidavit here.

Select...
Current High School

Select...
Next Year High School

Tulsa Tech does not discriminate on the basis of race, color, religion, national origin, gender, age, marital or veteran status, or disability.

Submit Application

Career Clusters Interest Survey

Name ______________________________

School ______________________________ Date ______________

Directions: Circle the items in each box that best describe you. You may make as many or as few circles in each box as you choose. Add up the number of circles in each box. Look to see which three boxes have the highest numbers. Find the corresponding Career Clusters on the pages immediately following this survey to see which Career Clusters you may want to explore.

BOX 1	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 1
	1. Learn how things grow and stay alive. 2. Make the best use of the earth's natural resources. 3. Hunt and/or fish. 4. Protect the environment. 5. Be outdoors in all kinds of weather. 6. Plan, budget, and keep records. 7. Operate machines and keep them in good repair.	1. Self-reliant 2. Nature lover 3. Physically active 4. Planner 5. Creative problem solver	1. Math 2. Life Sciences 3. Earth Sciences 4. Chemistry 5. Agriculture	

BOX 2	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 2
	1. Read and follow blueprints and/or instructions. 2. Picture in my mind what a finished product looks like. 3. Work with my hands. 4. Perform work that requires precise results. 5. Solve technical problems. 6. Visit and learn from beautiful, historic, or interesting buildings. 7. Follow logical, step-by-step procedures.	1. Curious 2. Good at following directions 3. Pay attention to detail 4. Good at visualizing possibilities 5. Patient and persistent	1. Math 2. Drafting 3. Physical Sciences 4. Construction Trades 5. Electrical Trades/Heat, Air Conditioning and Refrigeration/ Technology Education	

BOX 3	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 3
	1. Use my imagination to communicate new information to others. 2. Perform in front of others. 3. Read and write. 4. Play a musical instrument. 5. Perform creative, artistic activities. 6. Use video and recording technology. 7. Design brochures and posters.	1. Creative and imaginative 2. Good communicator/good vocabulary 3. Curious about new technology 4. Relate well to feelings and thoughts of others 5. Determined/tenacious	1. Art/Graphic design 2. Music 3. Speech and Drama 4. Journalism/Literature 5. Audiovisual Technologies	

Source: Adapted from the Guidance Division Survey, Oklahoma Department of Career and Technology Education (2005)

Note: *This survey does not make any claims of statistical reliability and has not been normed. It is intended for use as a guidance tool to generate discussion regarding careers and is valid for that purpose.*

BOX 4	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 4
	1. Perform routine, organized activities but can be flexible. 2. Work with numbers and detailed information. 3. Be the leader in a group. 4. Make business contact with people. 5. Work with computer programs. 6. Create reports and communicate ideas. 7. Plan my work and follow instructions without close supervision.	1. Organized 2. Practical and logical 3. Patient 4. Tactful 5. Responsible	1. Computer Applications/Business and Information Technology 2. Accounting 3. Math 4. English 5. Economics	

BOX 5	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 5
	1. Communicate with different types of people. 2. Help others with their homework or to learn new things. 3. Go to school. 4. Direct and plan activities for others. 5. Handle several responsibilities at once. 6. Acquire new information. 7. Help people overcome their challenges.	1. Friendly 2. Decision maker 3. Helpful 4. Innovative/Inquisitive 5. Good listener	1. Language Arts 2. Social Studies 3. Math 4. Science 5. Psychology	

BOX 6	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 6
	1. Work with numbers. 2. Work to meet a deadline. 3. Make predictions based on existing facts. 4. Have a framework of rules by which to operate. 5. Analyze financial information and interpret it to others. 6. Handle money with accuracy and reliability. 7. Take pride in the way I dress and look.	1. Trustworthy 2. Orderly 3. Self-confident 4. Logical 5. Methodical or efficient	1. Accounting 2. Math 3. Economics 4. Banking/Financial Services 5. Business Law	

BOX 7	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 7
	1. Be involved in politics. 2. Negotiate, defend, and debate ideas and topics. 3. Plan activities and work cooperatively with others. 4. Work with details. 5. Perform a variety of duties that may change often. 6. Analyze information and interpret it to others. 7. Travel and see things that are new to me.	1. Good communicator 2. Competitive 3. Service-minded 4. Well-organized 5. Problem solver	1. Government 2. Language Arts 3. History 4. Math 5. Foreign Language	

	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 8
BOX 8	1. Work under pressure. 2. Help sick people and animals. 3. Make decisions based on logic and information. 4. Participate in health and science classes. 5. Respond quickly and calmly in emergencies. 6. Work as a member of a team. 7. Follow guidelines precisely and meet strict standards of accuracy.	1. Compassionate and caring 2. Good at following directions 3. Conscientious and careful 4. Patient 5. Good listener	1. Biological Sciences 2. Chemistry 3. Math 4. Occupational Health classes 5. Language Arts	

	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 9
BOX 9	1. Investigate new places and activities. 2. Work with all ages and types of people. 3. Organize activities in which other people enjoy themselves. 4. Have a flexible schedule. 5. Help people make up their minds. 6. Communicate easily, tactfully, and courteously. 7. Learn about other cultures.	1. Tactful 2. Self-motivated 3. Works well with others 4. Outgoing 5. Slow to anger	1. Language Arts/Speech 2. Foreign Language 3. Social Sciences 4. Marketing 5. Food Services	

	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 10
BOX 10	1. Care about people, their needs, and their problems. 2. Participate in community services and/or volunteering. 3. Listen to other people's viewpoints. 4. Help people be at their best. 5. Work with people from preschool age to old age. 6. Think of new ways to do things. 7. Make friends with different kinds of people.	1. Good communicator/good listener 2. Caring 3. Non-materialistic 4. Intuitive and logical 5. Non-judgmental	1. Language Arts 2. Psychology/ Sociology 3. Family and Consumer Sciences 4. Finance 5. Foreign Language	

	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 11
BOX 11	1. Work with computers. 2. Reason clearly and logically to solve complex problems. 3. Use machines, techniques, and processes. 4. Read technical materials and diagrams and solve technical problems. 5. Adapt to change. 6. Play video games and figure out how they work. 7. Concentrate for long periods without being distracted.	1. Logical/analytical thinker 2. See details in the big picture 3. Persistent 4. Good concentration skills 5. Precise and accurate	1. Math 2. Science 3. Computer Tech/ Applications 4. Communications 5. Graphic Design	

	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 12
BOX 12	1. Work under pressure or in the face of danger. 2. Make decisions based on my own observations. 3. Interact with other people. 4. Be in positions of authority. 5. Respect rules and regulations. 6. Debate and win arguments. 7. Observe and analyze people's behavior.	1. Adventurous 2. Dependable 3. Community-minded 4. Decisive 5. Optimistic	1. Language Arts 2. Psychology/Sociology 3. Government/History 4. Law Enforcement 5. First Aid/First Responder	

BOX 13	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 13
	1. Work with my hands and learn that way. 2. Put things together. 3. Do routine, organized and accurate work. 4. Perform activities that produce tangible results. 5. Apply math to work out solutions. 6. Use hand and power tools and operate equipment/machinery. 7. Visualize objects in three dimensions from flat drawings.	1. Practical 2. Observant 3. Physically active 4. Step-by-step thinker 5. Coordinated	1. Math-Geometry 2. Chemistry 3. Trade and Industry courses 4. Physics 5. Language Arts	

BOX 14	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 14
	1. Shop and go to the mall. 2. Be in charge. 3. Make displays and promote ideas. 4. Give presentations and enjoy public speaking. 5. Persuade people to buy products or to participate in activities. 6. Communicate my ideas to other people. 7. Take advantage of opportunities to make extra money.	1. Enthusiastic 2. Competitive 3. Creative 4. Self-motivated 5. Persuasive	1. Language Arts 2. Math 3. Business Education/ Marketing 4. Economics 5. Computer Applications	

BOX 15	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 15
	1. Interpret formulas. 2. Find the answers to questions. 3. Work in a laboratory. 4. Figure out how things work and investigate new things. 5. Explore new technology. 6. Experiment to find the best way to do something. 7. Pay attention to details and help things be precise.	1. Detail-oriented 2. Inquisitive 3. Objective 4. Methodical 5. Mechanically inclined	1. Math 2. Science 3. Drafting/Computer-Aided Drafting 4. Electronics/Computer Networking 5. Technical Classes/ Technology Education	

BOX 16	Activities that describe what I like to do:	Personal qualities that describe me:	School subjects that I like:	Total number circled in Box 16
	1. Travel. 2. See well and have quick reflexes. 3. Solve mechanical problems. 4. Design efficient processes. 5. Anticipate needs and prepare to meet them. 6. Drive or ride. 7. Move things from one place to another.	1. Realistic 2. Mechanical 3. Coordinated 4. Observant 5. Planner	1. Math 2. Trade and Industry courses 3. Physical Sciences 4. Economics 5. Foreign Language	

Disclaimer: *Your interests may change over time. These survey results are intended to assist you with informal career exploration. Consider more formal assessments and other resources or services to help you plan your career. This survey does not make any claims of statistical reliability.*

The Sixteen Career Clusters

1 Agriculture, Food & Natural Resources	The production, processing, marketing, distribution, financing, and development of agricultural commodities and resources including food, fiber, wood products, natural resources, horticulture, and other plant and animal products/resources.
2 Architecture & Construction	Careers in designing, planning, managing, building, and maintaining the built environment.
3 Arts, A/V Technology & Communications	Designing, producing, exhibiting, performing, writing, and publishing multimedia content including visual and performing arts and design, journalism, and entertainment services.
4 Business, Management & Administration	Business Management and Administration careers encompass planning, organizing, directing and evaluating business functions essential to efficient and productive business operations. Business Management and Administration career opportunities are available in every sector of the economy.
5 Education & Training	Planning, managing, and providing education and training services, and related learning support services.
6 Finance	Planning, services for financial and investment planning, banking, insurance, and business financial management.
7 Government & Public Administration	Executing governmental functions to include governance; national security; foreign service; planning; revenue and taxation; regulation; and management and administration at the local, state, and federal levels.
8 Health Science	Planning, managing, and providing therapeutic services, diagnostic services, health informatics, support services, and biotechnology research and development.
9 Hospitality & Tourism	Hospitality and Tourism encompasses the management, marketing and operations of restaurants and other food services, lodging, attractions and recreation events, and travel-related services.

Career Clusters cont.

10 Human Services	Preparing individuals for employment in career pathways that relate to families and human needs.
11 Information Technology	Building linkages in IT occupations framework for entry-level, technical, and professional careers related to the design, development, support and management of hardware, software, multimedia, and systems integration services.
12 Law, Public Safety, Corrections & Security	Planning, managing, and providing legal, public safety, protective services and homeland security, including professional and technical support services.
13 Manufacturing	Planning, managing and performing the processing of materials into intermediate or final products and related professional and technical support activities such as production planning and control, maintenance, and manufacturing/process engineering.
14 Marketing, Sales & Service	Planning, managing, and performing marketing activities to reach organizational objectives.
15 Science, Technology, Engineering & Mathematics	Planning, managing, and providing scientific research and professional and technical services (e.g., physical science, social science, engineering), including laboratory and testing services, and research and development services.
16 Transportation, Distribution & Logistics	Planning, mangagement, and movement of people, materials, and goods by road, pipeline, air, rail and water and related professional and technical support services such as transportation infrastructure planning and management, logistics services, mobile equipment, and facility maintenance.

My top three Career Clusters of interest are:

1. ____

2. ____

3. ____

For more information, check with a career counselor at your high school, career technical center, higher education institution, or one-stop career center.

Assessment Information

View Application Status

High School applicants may provide standardized reading and math test scores from your high school (such as PLAN, Explore, Aspire, or ACT results) or take a reading and math test at Tulsa Tech. Applicants for Pre-Engineering at the high school locations need to submit a transcript (for review of math classes and grades) instead of math and reading test scores.

Adult applicants must take a reading and math test at Tulsa Tech, unless you have recent SAT/ACT scores or an official transcript confirming an Associate's degree or higher from an approved accredited college or university. The Practical Nursing program has different testing requirements; click here for information about the HESI A2 Test.

The Assessment Office is located in the Career Services Center on the Lemley Memorial Campus at 3420 S. Memorial Drive. Testing is available Monday through Thursday from 8:00 a.m. - 4:30 p.m. and Fridays from 8:00 a.m. - 1:30 p.m. Appointments are only required for Practical Nursing. You must bring a state-issued photo ID, such as a driver's license or current student ID. Click here for specific testing information or call 918.828.5000.

Schedule Program Visit

View Application Status

Please complete the form below to schedule a program visit. If you have any questions, please call 918.828.5260.

Students applying to the following programs do not need to complete a program visit:

- one hour Biomedical Sciences class at Union High School
- one hour Foundations of Manufacturing class at Broken Arrow High School
- one hour Pre-Engineering class at the high school locations
- one hour Web Design class at Jenks High School

After scheduling a program visit, the next step in the admissions process is to confirm your academic preparedness.

Sample Student

Program Name

Select...

Campus

Select...

Request Date

Choose Date

Request Time

7:30 AM

Schedule Visit

APPENDIX C

Survey

1. Name
2. Sex/Gender
    a. Male
    b. Female
    c. Prefer not to answer
3. Ethnicity
    a. American Indian or Alaska Native
    b. Asian
    c. Black or African American
    d. Native Hawaiian or Other Pacific Islander
    e. White
    f. Other
    g. Prefer not to answer
4. High School name and location

Mathematics Self-Efficacy Scale – Revised

Rate your ability to solve the following mathematical tasks on a scale from 1 to 5 with 1 = no confidence and 5 = complete confidence.

1. Add two large numbers e.g., 5739 + 62543) in your head.
2. Determine the amount of sales tax on a clothing purchase.
3. Figure out how much material to buy in order to make curtains.
4. Determine how much interest you will end up paying on a $675 loan over 2 years at 14 ¾% interest.
5. Use a scientific calculator.
6. Compute your car's gas mileage.
7. Calculate recipe quantities for a dinner for 41 when the original recipe is for 12 people.
8. Balance your checkbook without a mistake.
9. Understand how much interest you will earn on your savings account in 6 months, and how that interest is computed.
10. Figure out how long it will take to travel from City A to City B driving 55mph.
11. Set up a monthly budget for yourself.
12. Compute your income taxes for the year.
13. Understand a graph accompanying an article on business profits.

14. Figure out how much you would save if there is a 15% markdown on an item you wish to buy.
15. Estimate your grocery bill in your head as you pick up items.
16. Figure out which of two summer jobs is the better offer; one with a higher salary but no benefits, the other with a lower salary plus room, board, and travel expenses.
17. Figure out the tip on your part of a dinner bill split 8 ways.
18. Figure out how much lumber you need to buy in order to build a set of bookshelves.

Rate your ability to solve the following mathematical problems on a scale from 1 to 5

with 1 = no confidence and 5 = complete confidence.

19. In a certain triangle, the shortest side is 6 inches. The longest side is twice as long as the shortest side, and the third side is 3.4 inches shorter than the longest side. What is the sum of the three sides in inches?
20. ABOUT how many times larger than 614,360 is 30,668,000?
21. There are three numbers. The second is twice the first and the first is one-third of the other number. Their sum is 48. Find the largest number.
22. Five points are on a line. T is next to G. K is next to H. C is next to T. H is next to G. Determine the positions of the points along the line.
23. If y = 9 + x15, find x when y = 10.
24. A baseball player got two hits for three times at bat. This could be represented by 2/3. Which decimal would most closely represent this?
25. If P = M + N, then which of the following will be true?
    a. N=P-M
    b. P-N=M
    c. N+M=p
26. The hands of a clock form an obtuse angle at ----- o'clock.
27. Bridget buys a packet containing 9-cent and 13-cent stamps for $2.65. If there are 25 stamps in the packet, how many are 13-cent stamps?
28. On a certain map, 7/8 inch represents 200 miles. How far apart are two towns whose distance apart on the map is 3 1/2 inches?
29. Fred's bill for some household supplies was $13.64. If he paid for the items with a $20 bill, how much change should he receive?
30. Some people suggest that the following formula be used to determine the average weight for boys between the ages of 1 and 7: W = 17 + 5A where W is the weight in pounds and A is the boy's age in years. According to this formula, for each year older a boy gets, should his weight become more or less, and by how much?
31. Five spelling tests are to be given to Mary's class. Each test has a value of 25 points. Mary's average for the first four tests is 15. What is the highest possible average she can have on all five tests?
32. 3 4/5 - 1/2 = -----.
33. In an auditorium, the chairs are usually arranged so that there are x rows and y seats in a row. For a popular speaker, an extra row is added, and an extra seat is added

to every row. Thus, there are x + 1 rows and y + 1 seats in each row, and there will be (x + 1) and (y + 1) seats in the auditorium. Multiply (x + 1) (y + 1).

34. A ferris wheel measures 80 feet in circumference. The distance on the circle between two of the seats is 10 feet. Find the measure in degrees of the central angle SOT whose rays support the two seats.
35. Set up the problem to be done to find the number asked for in the expression "six less than twice 4 5/6"?
36. Two circles in the same plane with the same center and different radii are called -----.

Rate your ability to complete the following college course with a grade of B or better on a scale from 1 to 5 with 1 = no confidence and 5 = complete confidence.

37. Advanced calculus
38. Calculus
39. Biochemistry
40. Statistics
41. Computer science
42. Physiology
43. Trigonometry
44. Economics
45. Zoology
46. Accounting
47. Philosophy
48. Business administration
49. Geometry
50. Algebra II
51. Algebra I
52. Basic college math

Short Grit Scale (Grit-S)

Answer the following questions on a scale of 1 to 5. (1 = not at all like me and 5 = very much like me)

Consistency of interest

1. I often set a goal but later choose to pursue a different one.

2. I have been obsessed with a certain idea or project for a short time but later lost interest.
3. I have difficulty maintaining my focus on projects that take more than a few months to complete.
4. New ideas and projects sometimes distract me from previous ones.

Perseverance of effort

5. I finish whatever I begin.
6. Setbacks don’t discourage me.
7. I am diligent.
8. I am a hard worker.

Implicit Theory of Intelligence Scale

Answer the following on a scale of 1 to 6. (1 = strongly disagree and 6 = strongly agree)

9. You have a certain amount of intelligence and you really can’t do much to change it.
10. Your intelligence is something about you that you can’t change very much.
11. You can learn new things, but you can’t really change your basic intelligence.

TTC Specific Questions

12. Why did you choose to apply for TTC’s pre-engineering program?
13. Describe what your expectations were for the program.
14. Were your expectations met? Please explain.
15. Describe what the TTC pre-engineering program provided that you deem helpful for your success at the STEM Academy.

16. Describe what the TTC pre-engineering program provided that you deem not helpful for your success at the STEM Academy.

17. If you are choosing to not continue in TTC's pre-engineering program next year, please explain why.

18. Would you be willing to participate in a group interview about TTC's pre-engineering program?

    - Yes
    - No

19. How helpful were the following to your success at the STEM Academy? 1 = not helpful and 5 = very helpful

    - Your achievement in prior courses.
    - The class sizes at TTC.
    - The students at TTC.
    - The decrease in disruptive behavior at TTC.
    - Your peers are TTC.
    - The quality of teaching at TTC.
    - The teacher-student relationships at TTC
    - The use of inquiry-based teaching (learning through exploration) at TTC.
    - The use of direct instruction at TTC.
    - The use of problem-based teaching (learning in order to solve a problem) at TTC.
    - The use of cooperative learning at TTC.

20. How likely are you to continue a career in the engineering field? 1= not likely, 5 = very likely

21. How likely are you to continue your education I the engineering field? 1 = not likely, 5 = very likely

22. Describe your future career and/or educational plans.

23. What impacted these future career and/or educational plans?

APPENDIX D

Focus Question Interview Outline

Welcome and thank you for being here today. My name is Diana Early and I am a doctoral student at Oklahoma State University. The study that you are partaking in is focused on the characteristics of students that have completed one of the three pathways of TTC's pre-engineering program. This information will help TTC and other schools that have pre-engineering programs better support their students in completing a pre-engineering program.

You are here to help give some depth to the answers you have already provided in the survey emailed out previous to this interview. You all were chosen because of your willingness to volunteer and because of the certain pre-engineering pathway you completed here at TTC.

Before we get started, I want to go over some focus group guidelines that we will be following today. First, there are no wrong answers. All responses are your own opinion and therefore are not to be labeled as correct or incorrect. If another participant's response interests you, feel free to talk to each other – you do not have to be called upon to give a response. Since this interview will be recorded, I ask that only one person speak at a time. You may refer to each other and myself by first name during the interview. You do not have to agree with everything discussed today, but I do ask that you listen respectfully. I also ask that you silence any distractions during this interview to ensure minimal disruptions.

- Questions
    - Think back to when you were first interested in the pre-engineering program. What initially interested you in applying to the TTC pre-engineering program?
    - If you started the program at your high school, what interested you in continuing your enrollment at the academy for 11th and 12th grade?
    - Did the program meet your goals and expectations?
        - How so? Why not?
    - If you started the program at your high school, what was different/better there?
    - If you could change anything about the program, what would it be?
        - Why?
    - What does this program do that helped you be a successful completer of the pre-engineering program?
        - What could be done differently?
    - Has the knowledge you gained here in the pre-engineering program helped you in other areas or school or life?
    - What are your future educational plans?
        - Did the pre-engineering program influence any of these plans?
    - What are your future career plans?
        - Did the pre-engineering program influence any of these plans?
- Conclusion
    - Summary of answers

- Thanks
- The drawing for the gift card will be held on this day in the future.

APPENDIX E

IRB Approval

Oklahoma State University Institutional Review Board

Date:	Thursday, November 03, 2016
IRB Application No	#Type!
Proposal Title:	Exploring the Characteristics of Students of a Pre-Engineering Program
Reviewed and Processed as:	Exempt

Status Recommended by Reviewer(s): Approved   Protocol Expires: 11/2/2019

Principal Investigator(s):

Diana Early 614 S. Seminole St. Skiatook, OK 74070	Juliana Utley 233 Willard Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

☐ The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1. Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms.
2. Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3. Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4. Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Scott Hall (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Hugh Crethar, Chair
Institutional Review Board

Vita

Diana Early

Candidate for the Degree of

Doctor of Philosophy

Thesis: EXPLORING THE CHARACTERISTICS OF STUDENTS FROM A PRE-ENGINEERING PROGRAM

Major Field: Mathematics Education

Biographical:

Education:

Completed the requirements for the Doctor of Philosophy in Mathematics Education at Oklahoma State University, Stillwater, Oklahoma in July, 2017.

Completed the requirements for the Master of Science in Secondary Mathematics Education at Northeastern State University, Broken Arrow, OK in 2010.

Completed the requirements for the Bachelor of Science in Secondary Mathematics Education at Oklahoma State University. Stillwater, OK in 2007.

Experience:

Tulsa Technology Center, STEM Academy Instructor, Tulsa, OK from July 2017 to Present. Courses: Pre-Calculus, AP Computer Science Principles.

Skiatook High School, Teacher, Skiatook, OK from August 2008 to June 2014. Courses: Algebra I, Algebra II, Trigonometry/Pre-Calculus, ACT Prep.

Bartlesville High School, Teacher, Bartlesville, OK from August 2007 to July 2008. Courses: Geometry, Algebra II.

Professional Memberships:

Association for Career and Technical Education

National Council of Teachers of Mathematics