A STUDY ON THE PERSISTENCE OF OKLAHOMA STATE UNIVERSITY STUDENTS WHO COMPLETED A PRE-ENGINEERING PROGRAM AT TULSA TECHNOLOGY CENTER

By

TEDDY WYATT

Bachelor of Science in Electrical and Computer Engineering

Oklahoma State University

Stillwater, OK

1985

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A STUDY ON THE PERSISTENCE OF OKLAHOMA STATE UNIVERSITY STUDENTS WHO COMPLETED A PRE-ENGINEERING PROGRAM AT TULSA TECHNOLOGY CENTER

Thesis Approved:

Dr. Mary Jo Self

Thesis Adviser

Dr. Bernita Krumm

Dr. Juliana Utley

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Abstract: Science, Technology, Engineering, and Math (STEM) education has occupied an increasingly prominent place in American education policy and funding since the 1957 launch of Sputnik, culminating with an emphasis on STEM in the 2015 Every Student Succeeds Act. Pre-engineering education for high school students is one common response to the STEM emphasis with little formal data on efficacy of such programs. This research explores the persistence of 71 students in three cohorts of pre-engineering students from Tulsa Technology Center (TTC) at Oklahoma State University. The data suggest that the TTC pre-engineering program completers persist at OSU at a higher rate than does the general population of students that enroll in an engineering major at OSU.

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CHAPTER I

INTRODUCTION

Maintaining a vigorous and full pipeline of Science, Technology, Engineering and Mathematics (STEM) students at all educational levels is a national priority for continued competitiveness in the global economy (Every Student Succeeds Act, 2015; Obama, 2010; Roesel, 2010). A blue-ribbon committee chartered during the George W. Bush administration identified training and retaining engineers as a key priority for national competitiveness, citing the Project Lead the Way (PLTW) curriculum and professional development models as examples to be replicated (National Academy of Sciences, 2007). Business groups recognize the strategic importance of STEM education as evidenced by the 2005 launch of the Business Higher Education Forum's Securing America's Leadership in STEM Initiative with the objective of doubling the number of graduates in STEM majors by 2015 (Business Higher Education Forum, 2010), including a recommendation that high school programs designed to increase both proficiency and interest in STEM should be expanded. The Every Student Succeeds Act, the Obama administration's signature education bill, continued this emphasis by incentivizing states and local education agencies to develop STEM master teacher corps (2015).

The connection between science and math education and national competitiveness has been an important element of education strategies and policy discussions at the national level for more than 30 years (Gardner, 1983). Many researchers (Bybee & Ferrini-Mundy, 1997; Hare, 1999; Martin, 2011; O'Linn & Scott, 2008; Wissehr, Concannon, & Barrow, 2011) point to the launch of Sputnik in 1957 as the event that permanently established the importance of science and math education in United States federal education policy. Over time, the focus on math and science evolved to include all of STEM (Business Higher Education Forum, 2010; National Academy of Sciences, 2007). While the importance attached to STEM education and level of activity directed toward improving STEM performance is clear, some consider the developmental activities in science education during the Sputnik Era as "dynamic, momentous, as well as ineffective and futile" (Hare, 1999, p. 7).

With this evaluation in mind, one is not surprised that despite the high level of both public and policy-maker interest in increasing the number of STEM college graduates, the number of high school students entering college as engineering majors has declined (Noeth, Cruce, & Harmston, 2003), and the number of bachelor's degrees awarded in the United States for physical sciences, engineering and mathematics was essentially flat from 1989 to 2007 (Roesel, 2010). STEM graduation rates actually declined if they are calculated as either a percentage of all bachelor's degrees awarded or on a per capita basis (Business Higher Education Forum, 2010; Maltese & Tai, 2011). Efforts to increase the number of STEM graduates focus on both increasing the number of entrants into STEM majors and increasing student persistence in those majors. The Pre-Engineering curriculum published by Project Lead the Way (PLTW) was created to address both of these issues, and it has been cited as a model for engaging students in engineering and retaining them in STEM disciplines through post-secondary education (National Academy of Sciences, 2007; Wheeler, 2009). These claims notwithstanding, published research that examines the efficacy of PLTW courses with respect to student persistence either at the secondary or post-secondary level remains very rare (Cole, High, & Weinland, 2013; O'Linn & Scott, 2008; Wheeler, 2009). The purpose of this study is to add to the emerging body of research by exploring the persistence profile of students who completed Tulsa Technology Center's PLTW pre-engineering program and subsequently enrolled at Oklahoma State University (OSU).

Purpose of the Study

Cole et al. (2013) examined the persistence in engineering at Oklahoma State University among students who had taken PLTW courses at regional career technology centers while in high school, finding that there was no significant difference in persistence than for the general population of engineering students. This research examines the persistence of students at Oklahoma State University who completed a pre-engineering program of study at Tulsa Technology Center (TTC).

Statement of the Problem

Significant time and resources are devoted to pre-engineering courses in K-12 schools (Every Student Succeeds Act, 2015; PLTW, 2011) with the aim of increasing the number of students who graduate with university STEM degrees (Business Higher Education Forum, 2010; National Academy of Sciences, 2007). In the wake of decreasing funding for education in many fronts, pre-engineering programs face increased scrutiny due in part to limited research on the efficacy of the programs and lack of a consensus on how to quantify the impact of completion of a pre-engineering program on the eventual persistence to a STEM degree. This research seeks to add to the available data and propose a means of measuring the impact on persistence in specific related majors.

Conceptual Framework

The theoretical foundation for this research and the corresponding research questions begins with Tinto's persistence model (Tinto, 1987, 2006; Tinto & Cullen, 1973) that suggests factors affecting students' choices to continue in a higher education pursuit. Maltese and Tai (2011) refined Tinto's model to specifically identify factors related directly to STEM students including interest in engineering, cohort connections, math achievement, and experience with hands-on science. This refinement juxtaposed with the stated features of the PLTW pre-engineering curriculum (PLTW, 2011) suggests that students who persist in completing a pre-engineering program in high school will have received significant reinforcement of each of these factors prior to enrolling in a STEM degree (Martin, 2011; O'Linn & Scott, 2008). Self-Efficacy Theory (Bandura, 1977) suggests that at the point of enrollment, students who experienced significant success themselves and observed the success of others in pre-engineering would have higher expectations of their own success in a bachelor's program and greater confidence in their abilities in the STEM field, leading to a greater degree of persistence in STEM education. While Cole et al. (2013) did not find that to be true when examining the general case of former PLTW students persisting in engineering, this research examines whether completing an pre-engineering program of study suggests a higher degree of persistence in a STEM degree.

The conceptual framework for this study is illustrated in Figure 1. This research starts with students who have completed a pre-engineering program as represented by the first rectangle on the upper right of the figure, reflecting a goal commitment during high school in Tinto's model (Tinto & Cullen, 1973). The center arrow in the top portion of Figure 1 represents the positive influence of the PLTW pre-engineering sequence on STEM enrollment as claimed by PLTW (2011) and supported by O'Linn and Scott (2008). The third box on the top of the figure represents students who complete a STEM degree that is the desired outcome of efforts to increase the number of STEM graduates (Business Higher Education Forum, 2010).

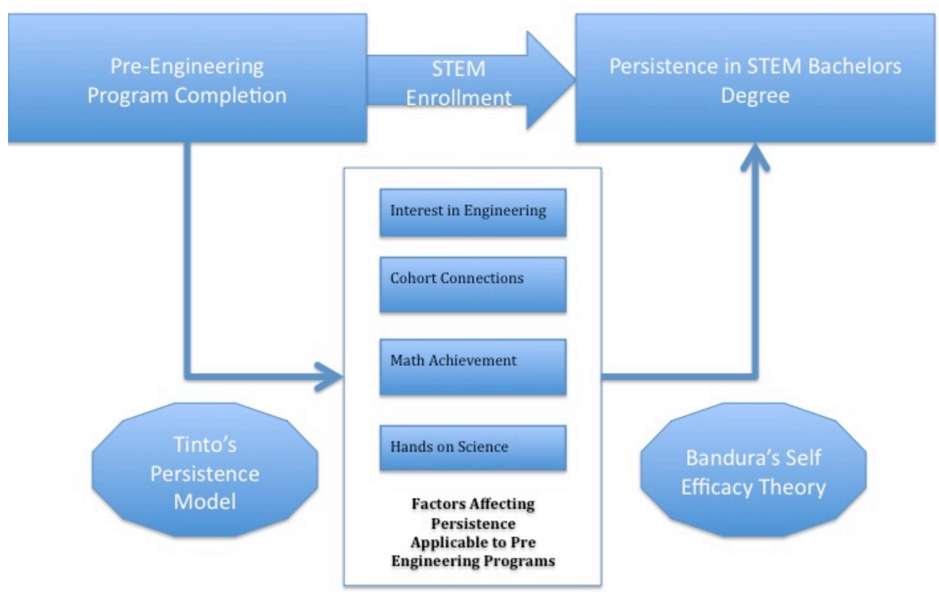

Figure 1: Conceptual Framework

Four factors that contribute positively toward STEM persistence according to Maltese and Tai (2011) are listed on the bottom center of the figure. Maltese and Tai showed that students who completed a STEM bachelor's degree identified these factors as contributors to their persistence to successful degree completion. These same four factors are also four of the advertised features of PLTW pre-engineering courses (PLTW, 2011).

Since increasing enrollment is only an intermediate step toward the national priority of increasing STEM graduates (Business Higher Education Forum, 2010), the next arrow in the figure represents the sequential influence of PLTW courses on students to not only enroll in a STEM major but to persist in a corresponding engineering major. According to Maltese and Tai's refinement of Tinto's persistence model (Tinto, 1987, 2006), students who receive significant reinforcement in interest in engineering, cohort connections, math achievement, and hands on science education should exhibit significantly higher levels of persistence than does the general population of STEM students. Cole et al. (2013) did not find that to be the case in general for students who had taken pre-engineering courses; however, this research explores whether persistence changes for students who complete a pre-engineering program.

Research Questions

The following research questions were developed to guide this study:

RQ1: What is the rate at which Tulsa Technology Center (TTC) pre-engineering program completers persist at Oklahoma State University (OSU)?

RQ2: What is the rate at which TTC pre-engineering program completers persist at OSU's College of Engineering, Architecture and Technology (CEAT) in particular?

RQ3: How does a TTC pre-engineering course completer who persists differ from one who does not persist in terms of:

a. pre-engineering course selection at TTC?

b. grades earned in the pre-engineering courses taken at TTC?

RQ4: What CEAT majors do TTC pre-engineering course completers who persist at OSU choose?

Researcher's Perspective

The researcher is a ten year veteran instructor in the TTC pre-engineering program and alumnus of OSU's College of Engineering. An ongoing dialogue among colleagues with personal and professional interests in the education of new engineers inspired this research. Some of the stakeholders involved in the discussion include pre-engineering instructors and administrators, parents of current and former pre-engineering students, practicing engineers, Project Lead the Way staff, and CEAT staff.

Definitions of Key Terms

Persistence

A construct that describes a student's choice to continue a course of study (Tinto & Cullen, 1973) that is essentially the complement of dropout rate. Operationally, persistence is usually measured either by whether a student remained enrolled at the eighth semester (Ohland et al., 2008) or by whether a student has attained a bachelor's degree by the end of the sixth year (Adelman, 2006). For the purposes of this study, the eight semester definition of persistence was used because six year graduation data was not yet available for the last cohort under study.

Program Completer

For the cohorts studied in this research, Tulsa Technology Center defined a pre-engineering program completer as a student who earned a C or better in Engineering Design and Development (EDD), Digital Electronics (DE), Civil Engineering and

Architecture (CEA), Introduction to Engineering Design (IED) and Principles of Engineering POE) in addition to two math or science courses (M. Oates, personal communication, May 24, 2016). The pre-engineering courses listed all use the standardized curriculum and professional development provided by PLTW.

Project Lead the Way (PLTW)

"…a nonprofit organization that provides a transformative learning experience for K-12 students and teachers across the U.S." (PLTW, 2011). PLTW provides nationally standardized curriculum, professional development and assessment resources used to implement pre-engineering courses at TTC.

Pre-engineering

K-12 courses aimed at encouraging students to explore or enroll in engineering majors in college. While PLTW is not the sole provider of pre-engineering curriculum, the proposed research examines only PLTW courses offered at Tulsa Technology Center.

Science, Technology, Engineering, and Math (STEM) Academy

A distributed campus consisting of eight instructors (during the time period addressed by this research) teaching Introduction to Engineering Design and Principles of Engineering to freshman and sophomore students in eight Tulsa, Oklahoma area high schools. In addition, the STEM Academy included seven instructors co-located on TTC's Memorial Complex who taught the remaining pre-engineering and math courses.

CHAPTER II

LITERATURE REVIEW

The literature review focused on three areas: general persistence theory, persistence in STEM fields, and the effects of Project Lead the Way (PLTW) courses on STEM persistence. Literature concerning general persistence theory was reviewed along with some leading competing theories to establish the theoretical context for persistence in higher education, to obtain accepted operational definitions of persistence, and to understand historical norms of overall persistence rates. Literature more specific to persistence in the STEM fields was reviewed to identify factors contributing to STEM persistence, persistence rates, and methods of measuring persistence. Finally, the limited published research related to the effects of Project Lead The Way pre-engineering courses on persistence or performance was reviewed.

Persistence Theory

The formal study of the percentage of students who complete a college degree and factors that affect that percentage dates to the late 19th century, but the construction of persistence theory began in earnest in the 1970s (Berger & Lyon, 2005). Early researchers eventually arrived at four main terms describing the number of students that

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complete a bachelor's degree compared with the number that start the process: attrition, dropout, persistence, and retention (Berger & Lyon, 2005; Hagedorn, 2005).

Tinto and Cullen wrestled with the term dropout, finding that it lacked sufficient flexibility to account for student transfers between institutions as they analyzed university dropout data reported in several studies from the late 1960s and early 1970s. A new construct called "goal commitment" (Tinto & Cullen, 1973, p. 41) was identified by Tinto and Cullen as a key factor in dropout decisions and is a central feature of their theoretical model that identifies characteristics of both the student and the university setting that affected student decisions to drop out. Important individual characteristics of the student included academic ability, gender, and the type of high school attended. These factors were found to be much more influential on persistence decisions than family background (Tinto & Cullen, 1973). Across all institution types, the 1966 freshmen class of college students experienced a 24% dropout rate --76% persistence rate-- after four years.

In a longitudinal study of more than 41,000 members of the 1968 freshman class of university students, Astin (1975) added the term stopout to describe students who had temporarily suspended their studies but fully intended to complete a four year degree. In his study, Astin examined the usual factors associated with persistence studies including high school grades, family background, gender, and race while also examining university environmental factors including the students' residence and participation in extracurricular activities, finding that both choosing to live in a dormitory and being involved in activities contributed to higher persistence rates (Astin). Overall, the freshman class of 1968 experienced a 50% persistence rate when measured as degree attainment after four years (Astin).

By 1984, the published research on persistence in college was voluminous and diverse to the point of creating “confusion and perplexity” (Astin, 1984, p. 514). At the same time, higher education institutions were increasingly looking to the research into persistence, dropouts, and retention to help manage rapidly changing enrollment (Berger & Lyon, 2005). Seeking a simple unifying idea to explain the available data and to provide both researchers and university administration with a tool to improve student graduation rates, Astin (1984) proposed Involvement Theory with student involvement as the unifying construct central to determining persistence. An involved student was characterized as one who “devotes considerable energy to studying, spends much time on campus, participates actively in student organizations, and interacts frequently with faculty members and other students” (Astin, 1984, p. 514). Involvement is a measure of the energy invested by the student in the college experience; higher involvement results in greater student development and greater persistence (Astin, 1984).

Tinto (1987) also undertook to bring order to the research in college persistence, but chose to propose Interactionalist Theory as a comprehensive model of institutional departure that incorporated family characteristics, student attributes and elements of the university setting. In this model, similar to Involvement Theory (Astin, 1984), student persistence depends upon the full integration of the student into the university community (Tinto, 1987). Malintegration, on the other hand, is a significant cause of departure decisions which Tinto explained using concepts from Suicide Theory (Durkheim, 1951) as a framework. Tinto's Interactionalist Theory ascended to the point of "enjoying paradigmatic stature" (Braxton & Hirschy, 2005).

Persistence research, persistence data and the ability to analyze the data matured steadily in the 1990s and early 21st century (Berger & Lyon, 2005). Astin and Oseguera (2005) analyzed degree attainment data from 56,818 members of the college freshman class of 1994 from 262 institutions across the United States and found attainment rates of 36% after four years, 58% after six years and 61% after more than six years. Both institutional and individual factors were analyzed with the goal of obtaining linear models for predicting degree attainment given a subset of the input variables high school grades, SAT Verbal and Math scores, gender, and race. However, the multiple R regression coefficient of 0.36 for the four year degree attainment model only accounts for 13% of the variance in persistence. It is also of interest to note that the model for degree attainment after more than six years has a multiple R of 0.30, suggesting that other factors contribute more to the variance as students take longer to obtain their degrees.

Using the NELS:1988 data set which included a sample of more than 12,000 students from the 2.9 million eighth graders in 1988, Adelman (2006) arrived at a 66% persistence rate for all students in all majors in institutions throughout the United States. This is reasonably consistent with the 61% degree attainment after 6 or more years published by Astin and Oseguera (2005). Adelman also investigated issues contributing to persistence and cited high school curriculum as the dominant factor in preparing a student for completion of an undergraduate degree. Adelman's research provided a significant adjustment to the conversation on persistence by establishing that degree completion within six to eight years is the proper measure of persistence, although during this time a student may drop out of one or more institutions or change majors more than once. Cabrera, Burkum, and La Nasa (2005) based their investigation into how persistence is affected by transfers on Adelman's findings.

Persistence in the STEM Majors

As the literature describing persistence in general stabilized, research into persistence in specific disciplines emerged. Hilton and Lee (1988) used data from samples of the 1972 and 1982 high school graduating classes to examine the percentages of students pursuing a STEM education path. Less than 30% of high school seniors who reported plans to pursue a STEM degree actually completed a STEM bachelor's degree, with the most significant loss occurring during the transition from high school to college (Hilton & Lee, 1988). Once enrolled in a STEM major as a freshman in college, 60% of students completed a STEM degree, prompting Hilton and Lee to conclude that preparation for and commitment to a STEM career during high school is critical.

Strenta, Elliott, Adair, Matier, and Scott (1994) set out to explain the lack of persistence among high-ability students at four highly selective universities using data from a sample of 5,320 students. Their findings were similar to Hilton and Lee (1988) in that only about 40% of the students expressing interest in STEM as high school seniors ultimately completed a bachelor's degree in a STEM field (Strenta et al., 1994). The majority of students who left STEM fields chose to leave due to the attractiveness of alternate fields of study.

Zhang, Anderson, Ohland, and Thorndyke (2004) examined how several factors including high school GPA, SAT score, gender, ethnicity, and citizenship, affected graduation with a STEM degree at universities in the southeastern United States using a longitudinal database from the Southern University and College Coalition for Engineering Education. Analysis showed that only high school GPA and math SAT score had a statistically significant positive correlation to STEM persistence at all of the universities represented in the study. However, the factors examined accounted for only 5% to 24% of the variance in likelihood of graduation with a STEM degree at the studied universities.

Citing analysis performed at Mercer University (2002), Burtner and Backer (2004) claimed that only 24% of the variance in persistence in engineering was attributable to high school grades and SAT scores. They used data from the Pittsburg Freshman Engineering Attitudes Survey from 116 engineering students in the fall 2000 cohort to analyze factors critical to persistence in engineering, concluding that

the five critical-to-quality factors associated with persistence toward an engineering degree were 1) high school grade point average, 2) first year college grade point average, 3) confidence in study habits, 4) the degree to which the student likes the study of engineering or the engineering profession, and 5) perception of high pay and job security. (Burtner & Backer, 2004, p.4). Their analysis is based on ANOVA analysis of attitude scores among students who left the engineering major during the first year and those who stayed in engineering after the first year.

Ohland et al. (2008) compiled data for more than 73,000 students from two longitudinal databases to determine persistence rates after eight semesters of enrollment across all majors. Engineering majors exhibited the highest persistence at 57% while computer science majors had the lowest persistence level at 38%. Based on these results, they arrive at the bold conclusion "To the extent that educators and policymakers have concerns about the dearth of engineers being prepared in this country, our data provide compelling evidence that lack of retention is not the major cause of the deficiency" (Ohland et al., 2008, p. 274).

Lord et al. (2009) examined persistence in engineering by race and gender, using one of the same databases as Ohland et al. (2008). Lord expanded on Ohland's rationale for using the eighth-semester definition of persistence instead of the six year graduation rate promoted by Adelman (2006) because of the increased population under study due to the inclusion of large segments of cohorts that complete degrees in less than six years. The conclusion that females are nearly as likely to persist in engineering as males is contrary to the "pervasive popular belief that women persist at lower rates than men" (Lord et al., 2009, p. 169). Overall, they found that 55% of students who started in STEM persisted to the eighth semester.

A STEM persistence model developed by Raytheon and published by the Business Higher Education Forum (2010) proposed interest in STEM and math ability as the two key factors affecting persistence. The model is unique in that it draws on principles of systems dynamics to evaluate factors to increase the number of STEM graduates; however, it has not gained much traction among researchers or policy makers.

Maltese and Tai (2011) built on the persistence model developed by Adelman (2006), focusing on factors contributing to persistence in STEM specifically. This study introduced and validated the concept of using 16 or more completed higher-level STEM classes as a proxy for measuring completion of a STEM bachelor's degree. Developing a student's commitment during high school to pursue a STEM degree is crucial because seniors "who indicated a major in a STEM field were more than three times as likely to earn a STEM degree as those who were planning for a different major" (Maltese & Tai, 2011, p. 899). This factor, along with the number of STEM credits completed during the first year of college, was found to be the most significant factor in the logistic model of STEM persistence proposed by Maltese and Tai (2011).

Impacts of PLTW Pre-engineering Courses

Pre-engineering is an emerging, rapidly growing phenomenon in secondary education (Bottoms & Anthony, 2005; Cole et al., 2013; Fantz, 2009; Frabutt, Holter, & Nuzzi, 2008; Martin, 2011; O'Linn & Scott, 2008; PLTW, 2011; Wheeler, 2009) with relatively little published data on how performance or persistence in such a program may impact persistence in college. One early study by Wheeler (2009) examined the efficacy of PLTW courses in improving students' math achievement, citing the criticality of mathematics ability to success in engineering as justification for the study. Student mathematics ability was baselined at the end of the eighth grade using the Missouri Assessment Program mathematics score. Students who enrolled in PLTW courses in the ninth and/or tenth grade were considered the treatment group while students who did not enroll in PLTW courses were considered to be the control group. Mathematics scores on the tenth grade Missouri Assessment Program were used as the post-test. A regression analysis showed that participating in the PLTW courses did not contribute significantly to mathematics achievement (Wheeler, 2009). Wheeler found that pre-engineering completers did enroll in engineering in college at a significantly higher rate than the general population, but the study did not provide information for persistence in college.

Fantz (2009) surveyed 332 engineering students at Colorado State University to understand self-efficacy development through engineering exposure before college.

Exposure events included field trips, summer camps, and classes including, but not limited, to PLTW courses. Exposure information from a survey was operationalized by converting experiences into a day equivalent. The survey also included questions to measure self-efficacy (Bandura, 1977), resulting in a self-efficacy score for each student. A linear regression analysis between engineering exposure and self-efficacy resulted in a small but statistically significant correlation $F(1,330) = 12.46$, $p < .001$ (Fantz, 2009). With an R^2 of .03, pre-college engineering exposure explains only 3% of the variance in engineering self-efficacy. Nevertheless, further research into the effect of rigorous K-12 programs on engineering self-efficacy is suggested, based on a hypothesis that "students who are exposed to complex engineering problems during K-12 instruction and taught problem-solving skills to work through them will have higher self-efficacy for challenges in college engineering coursework" (Fantz, 2009, p. 87).

Martin (2011) used the survey developed by (Fantz, 2009) to examine the effect of PLTW courses on self-efficacy of black students using a sample of 76 students enrolled in PLTW courses. Martin found that students in two PLTW courses in particular, Principles of Engineering and Computer Integrated Manufacturing, had significantly higher engineering self-efficacy scores than students enrolled in other PLTW courses.

O'Linn and Scott's (2008) study closely matches the objective of the proposed research by examining the impact of one pre-engineering program at a Catholic school in Indiana on successful completion of engineering study. O'Linn and Scott surveyed 49 graduates of the PLTW pre-engineering program finding that 41% were enrolled in or had completed an engineering degree. Survey respondents also agreed or highly agreed that the pre-engineering program had developed the following essential competencies for engineering school: teamwork (87%), design tools (75%), electrical engineering (71%), drawing tools (69%) and general computer use (62%). While the study suggests a positive influence of the pre-engineering program on both the choice of engineering as a college major and perceived preparation for engineering school, the small, exclusive sample size limits the conclusions that can be drawn from the research.

Cole et al. (2013) examined persistence of students at Oklahoma State University in the College of Engineering, Architecture and Technology, comparing the general population with those who entered having completed a sequence of PLTW pre-engineering courses in high school. The study followed cohorts ranging in size from 5 to 36 entering the university as engineering majors in Fall 2005 through Fall 2009. Students who remained enrolled in engineering or who had graduated with a degree in engineering were considered persisters. This study showed no statistically significant difference in persistence between students who had completed a pre-engineering program and the general population of engineering students.

CHAPTER III

METHODOLOGY

Research Design

This quantitative study analyzes how the students in three cohorts of pre-engineering program completers progress through post-secondary education at Oklahoma State University. In keeping with the characteristics of a quantitative research project (Creswell, 2012), the project began with observations by the researcher and others that stakeholders in engineering education were asking whether pre-engineering programs in general and Tulsa Technology Center's (TTC) program in particular produced students that performed differently in college than students who did not take pre-engineering courses. A review of the literature suggested that more research into the topic was warranted and that one construct that could be fruitfully explored was the persistence of pre-engineering students in college, leading directly to the statement of purpose that guided the remainder of the study.

Continuing to follow the research outline described by Creswell (2012), an iterative process of drafting research questions and exploring the possible data sources to address the questions ensued. This process culminated with four final research questions.

RQ1: What is the rate at which Tulsa Technology Center (TTC) pre-engineering program completers persist at Oklahoma State University (OSU)?

RQ2: What is the rate at which TTC pre-engineering program completers persist at OSU's College of Engineering, Architecture and Technology (CEAT) in particular?

RQ3: How does a TTC pre-engineering course completer who persists differ from one who does not persist in terms of:

a. pre-engineering course selection at TTC?
b. grades earned in the pre-engineering courses taken at TTC?

RQ4: What CEAT majors do TTC pre-engineering course completers who persist at OSU choose?

A dataset to address the questions was developed following an approved Institutional Review Board Approval Form and with written permission from Tulsa Technology Center. Subsequent chapters present the analysis of the data and the conclusions drawn from that analysis.

Population

The study population consisted of 71 graduates from Tulsa Technology Center's STEM Academy who completed a pre-engineering program of study in 2009, 2010 and 2011 and also enrolled at OSU in subsequent semesters. This population was selected due to availability of the data to the researcher. The specific TTC data used included: student name (only for administratively matching with OSU enrollment data), list of PLTW courses completed, grades earned in the PLTW courses, and high school graduation year. Data were obtained with permission from the TTC superintendent.

Data were analyzed for each cohort by semester since enrollment to determine the number of students in enrolled, dropped or graduated status similar to Cole et al. (2013).

Procedures

The following steps were used to obtain and analyze the data for this research:

1. The researcher was added as a co-principal investigator to an existing, approved Institutional Review Board (IRB) Approval Form for a similar project. The IRB approval was subsequently modified to limit the scope of the research to a smaller population (Appendix A).
2. Permission was obtained from the TTC Superintendent, Dr. Steve Tiger to use historical student data (Appendix B).
3. The study population was defined by identifying students who had self-reported an intent to attend OSU. There was no attempt to follow up on students' expressed intent, nor were there activities to facilitate or intervene in students' enrollment activities. There was no contact between the students in the population and the researcher.
4. Transcripts for students in the study population were provided to the researcher by the STEM Academy registrar.
5. The researcher provided the student names to his OSU adviser who administratively matched the names with OSU enrollment information. In a few instances where first name and surname were inadequate to unambiguously match the TTC information with the OSU information, student birthdates were used for a final match, when possible.

6. The researcher assigned a non-identifiable tracking number to replace student names for study purposes.
7. The dataset for this study was constructed in an Excel spreadsheet consisting of the tracking number, cohort year, pre-engineering courses taken and corresponding grades, OSU major and enrollment status by semester.

Data Analysis

Students' status at OSU was categorized in the Excel spreadsheet hierarchically to examine overall persistence, persistence in a STEM major, persistence in CEAT and finally, persistence in specific CEAT majors. Formulas were added to the spreadsheet to tabulate the number of students in each cohort and enrollment status category. Average persistence rates were calculated to compare with previously published persistence data. Results of the analyses are provided in the tables in Chapter IV.

CHAPTER IV

FINDINGS

Introduction

The purpose of this chapter is to communicate the results of the study based on the analysis of the data.

Purpose and Objectives

This research examines the persistence of students at Oklahoma State University who completed a pre-engineering program of study at Tulsa Technology Center (TTC).

Descriptive Findings

The initial stratification of students in the population (n=71) was by overall enrollment status at OSU. Students who enrolled at OSU for at least one class in any discipline were categorized as enrolled at OSU (n=56). Students who were accepted to OSU but never enrolled, students for whom there is no record at all at OSU, and students who could not be unambiguously identified with the information available to the researcher were categorized as not enrolled at OSU (n=15). There was no attempt to locate students in the not enrolled category beyond the administrative matching process described for all students in the population since the purpose of the study and the research questions limit the scope of the study to persistence at OSU.

Table 1 – *Enrollment Status at OSU*

	Enrolled at OSU		Not Enrolled at OSU	
	Freq.	%	Freq.	%
2008-2009 Cohort	15	83.3	3	16.7
2009-2010 Cohort	20	71.4	8	28.6
2010-2011 Cohort	21	77.8	4	16.0
Total All Cohorts	56	78.9	15	21.1

For students in the study population who enrolled at OSU, persistence status was then determined by cohort according to the operational definition of persistence. Students who remained enrolled at the eighth semester (n= 45) were categorized as persisters (see Table 2). Students who had taken at least one class but no longer met the definition of persister were categorized as non-persists (n=11). There was no attempt to follow up on the non-persisters or otherwise determine the circumstances or reasons for non-persistence. Table 2 directly addresses RQ1: What is the rate at which Tulsa Technology Center (TTC) pre-engineering program completers persist at Oklahoma State University (OSU)?

Table 2 – *Persistence Status by Cohort*

	Persisters		Non-Persisters		Enrolled at OSU	
	Freq.	%	Freq.	%	Freq.	%
2008-2009 Cohort	13	86.7	2	13.3	15	100
2009-2010 Cohort	18	64.3	2	7.1	28	100
2010-2011 Cohort	14	56.0	7	28.0	21	100
Total All Cohorts	45	80.4	11	19.6	56	100

Persisters within each cohort were then further categorized based on their major area of study (see Table 3). Majors within the College of Engineering, Architecture, and Technology (CEAT) were categorized as CEAT (n=39). Majors within the physical sciences, life sciences, or mathematics were categorized as STEM (n=4). Other majors not falling within either of these groups were categorized as Non-STEM (n=2). Table 3 directly addresses RQ2: What is the rate at which TTC pre-engineering program completers persist at OSU's College of Engineering, Architecture and Technology (CEAT) in particular?

Table 3 –*Majors of Persisters by Cohort*

	CEAT		STEM		Non-STEM		Total Persisters	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
2008-2009 Cohort	11	84.5	1	7.7	1	7.7	13	100
2009-2010 Cohort	16	88.9	2	11.1	0	0.0	18	100
2010-2011 Cohort	12	85.7	1	7.14	1	7.14	14	100
Total All Cohorts	39	86.7	4	8.9	2	4.4	45	100

RQ3 asked: How does a TTC pre-engineering course completer who persists differ from one who does not persist in terms of:

a. pre-engineering course selection at TTC?

b. grades earned in the pre-engineering courses taken at TTC?

In the Tulsa Technology Center pre-engineering implementation in effect for these cohorts, completers were required to earn a C or better in Engineering Design and Development (EDD) during their senior year. EDD is a capstone design class that focuses on executing a design process in a team environment for a large project rather than specific skills or knowledge in a particular subject area. The first row of Table 4 shows the grades earned in EDD in aggregate (not by cohort) categorized by persistence status.

Senior students must also earn a C or better in an elective class chosen from Aerospace Engineering or Computer Integrated Manufacturing. Aerospace Engineering is an applied physics class addressing key concepts in both atmospheric and exoatmospheric flight. Computer Integrated Manufacturing is course in manufacturing automation and robotics. Aggregate student choices among these two courses are tabulated according to persistence status along with the average grade in that category in Table 4.

Table 4 – *Senior courses and grades by persistence status*

	Persisters		Non-Persisters		Total	
	Freq.	Grade	Freq.	Grade	Freq.	Grade
Engineering Design and Development	45	3.87	11	3.36	56	3.67
Aerospace Engineering	21	3.80	8	3.38	29	3.56
Computer Integrated Manufacturing	24	3.75	3	3.67	27	3.50
Total AE and CIM	45		11		56	

RQ4 asked: What CEAT majors do TTC pre-engineering course completers who persist at OSU choose? To address this question, the number of students in each CEAT major was tabulated by cohort. Only majors selected by at least one student are listed. In cases where a student changed majors, the final major was used. Students with dual degrees were categorized based on the one listed first on their transcript (see Table 5).

Table 5 – *CEAT Majors for Persisters by Cohort*

	2008-2009 Cohort Freq.	2009-2010 Cohort Freq.	2010-2011 Cohort Freq.	Overall Freq.	Overall %
Mechanical Engineering	3	3	4	10	25.6
Aerospace Engineering	2	1	2	5	12.8
Electrical Engineering	1	3	0	4	10.3
Mechanical Engineering Technology	0	2	2	4	10.3
Architecture	1	1	1	3	7.7
Chemical Engineering	2	0	1	3	7.7
Civil Engineering	0	3	0	3	7.7
Electrical Engineering Technology	0	1	1	2	5.1
Computer Engineering	1	1	1	2	5.1
Construction Management Technology	0	1	0	2	5.1
Fire Protection Technology	1	0	0	1	2.6
Total All Majors	11	16	12	39	100

CHAPTER V

CONCLUSIONS

Introduction

Chapter I introduced the issue of persistence in STEM education as it relates to the national priority of maintaining a workforce that is well educated in STEM subjects in order to remain competitive and secure in the global economy. The necessary terms and conceptual framework were provided in order to establish context for the research questions and the purpose of the study.

Chapter II brought together the key concepts from existing research concerning general persistence theory, persistence in the STEM fields, and the effects of Project Lead The Way pre-engineering courses on persistence in STEM. Taken as a whole, the literature suggests that research into both what affects persistence decisions and why students persist remain fields with many opportunities for discovery.

Chapter III described the methods to collect and organize data from the study population consisting of 71 program completers from Tulsa Technology Center's STEM Academy in 2009, 2010 and 2011 who also enrolled at OSU.

Chapter IV presented the categorized data from the 71 members of the study population. Frequencies and percentages were calculated for persisters, non-persisters and non-located students. Persisters were subcategorized into CEAT, other STEM and non STEM. CEAT persisters were categorized by major and by pre-engineering course selection profile.

The remainder of Chapter V provides a summary of the findings, conclusions, limitations of the study and author recommendations for additional research.

Purpose

Substantial education resources are invested at the local, state and national level to provide and emphasize STEM education in K-12 with little conclusive research showing whether those investments achieve the desired result of improving and expanding the STEM workforce or the engineering workforce. This study examines completers of the Tulsa Technology Center (TTC) pre-engineering program as they furthered their studies at Oklahoma State University.

Objective

The objective of this study was to examine the persistence profile of three cohorts of Oklahoma State University Students that were also program completers pre-engineering at TTC. The study analyzed the TTC transcripts of 71 students who had self-reported an intent to enroll at OSU. Student names were administratively matched with OSU enrollment data to determine their enrollment status and major.

Findings

RQ1: What is the rate at which Tulsa Technology Center (TTC) pre-engineering program completers persist at Oklahoma State University (OSU)?

Students in the cohorts under study who enrolled at OSU for at least one class ultimately persisted at a rate of 56 to 86.7%. Overall persistence calculated without respect to cohort was 80.4%. For the population under study, the results suggest that TTC program completers persist at OSU a higher rate than reported by Adelman (2006) who reported for college students in general "..between 54 and 58 percent will earn the degree from the same school in which they began within six years of entry" (p. 87).

RQ2: What is the rate at which TTC pre-engineering program completers persist at OSU's College of Engineering, Architecture and Technology (CEAT) in particular?

Students in the cohorts under study who persisted at OSU ultimately persisted in a CEAT major at a rate of 84.5 to 88.9%. This represents 69.6% of the TTC pre-engineering program completers who enrolled in at least one class at OSU. By comparison for the 2006 CEAT enrolling cohort, 70% persisted in some major at OSU while 47% persisted in a CEAT major (Cole, et al, 2013).

RQ3: How does a TTC pre-engineering course completer who persists differ from one who does not persist in terms of:

a. pre-engineering course selection at TTC?

b. grades earned in the pre-engineering courses taken at TTC?

For the cohorts under study, persisters chose their elective pre-engineering class in similar numbers: 24 selected Aerospace Engineering (AE) while 21 chose Computer Integrated Manufacturing (CIM). Non-persisters, however, were more likely to choose AE (f=8) than CIM (f=3). The average grade of persisters in AE (3.80) and CIM (3.75) were also similar, but the grades of non-persisters in AE (3.38) were lower than non-persisters in CIM (3.67). While this suggests a relationship between grades in AE and persistence, the number of students in the different categories was too small to support meaningful statistical analysis.

Student grades in Engineering Design and Development, the required senior capstone class, were also examined. For the cohorts under study, the average grade for persisters was 3.87 while the average grade for non-persisters was 3.36. Table 6 presents persistence status by EDD course grade.

Table 6 – *EDD Grades by Enrollment Status at OSU*

	Persister		Non-Persister	
	Freq.	%	Freq.	%
A in EDD	39	69.6	4	7.1
B in EDD	6	10.7	7	12.5
Total	45	80.4	11	19.6

RQ4: What CEAT majors do TTC pre-engineering course completers who persist at OSU choose?

Majors for persisters were tabulated with 48.7% of students studying in mechanical disciplines (Mechanical Engineering, Aerospace Engineering and Mechanical Engineering Technology). Electrical disciplines (Electrical Engineering, Computer Engineering and Electrical Engineering Technology) accounted for 20.5% of CEAT persisters. Five other majors accounted for the remaining 30.8% of CEAT persisters. The number of students in each category was too small to support meaningful statistical analysis of pre-engineering course selection or grades with respect to persistence in a particular major.

Discussion

This study, like many others (Cole et al., 2013; Fantz, 2009; Frabutt, Holter, & Nuzzi, 2008; Martin, 2011; O'Linn & Scott, 2008; Wheeler, 2009) attempts to bridge the data gap that exists between high school and college by following three known cohorts of a single university. The results of this study suggest that TTC pre-engineering completers who attend OSU persist at a rate somewhat higher than the general population of college students reported by Adelman (2006). The study also suggests that TTC pre-engineering completers who attend OSU may persist at a higher rate than the general population of OSU CEAT students or other pre-engineering students reported by Cole, et al (2013).

This study suggests that students' performance in the capstone PLTW course may provide an early indicator of non-persistence. Students who earned an A in EDD and enrolled at OSU persisted at a rate of 88%, while 46% of students who earned a B or lower in EDD persisted. Because success in EDD depends primarily on executing and documenting a detailed engineering design process and not so much on academic ability or performance, earning an A in EDD may reflect a goal commitment to engineering (Tinto & Cullen, 1973) whereas earning a lower grade may reflect a lower level of goal commitment to further education in general or engineering in particular. It is noteworthy that the 88% persistence rate for students who earned an A in EDD is higher than the persistence reported by Cole, et al (2013) or Adelman (2006).

Limitations of the Study

There are many limitations to this study. First, it examined only 71 students from TTC attending OSU. The results cannot be extended to the tens of thousands of pre-engineering program completers attending other universities. The process of identifying completers and obtaining the pre-engineering course data is a daunting task as is finding those students and obtaining college persistence information.

Second, this study makes no attempt to evaluate the effect of gender, socioeconomic status, home high school or other factors that may affect persistence in college. The small number of students in each cohort resulted in many subclassifications of interest having no qualifying students.

Third, there is no attempt to resolve the academic status of students who entered the dropped status. Those students may have persisted at a different university.

Applications to Practice

The results of this study suggest that completing the TTC pre-engineering program has a positive influence on persistence in a STEM degree at OSU. While these results are not formally extensible to other pre-engineering providers or universities, it can be argued that similar results may be expected from any PLTW implementation due to the emphasis on standardized curriculum and exceptional professional development (National Academy of Sciences, 2007). Secondary schools and technology centers currently offering pre-engineering courses should continue to do so with confidence in the positive influence on college persistence.

Schools and technology centers that do not currently offer pre-engineering courses can use the results of this study to inform discussions concerning adding such courses. Rural or small schools in Oklahoma that lack the critical mass of students needed for pre-engineering classes or the funding to implement them can use the results of this study to lobby their technology center to add pre-engineering program. Proposals to obtain financial incentives provided by the Every Student Succeeds Act (2015) for regional alliances to expand STEM education in rural areas should include the results of this study as part of the support for the proposal.

The results of this study should be included in professional development for high school counselors to inform their discussions with students and parents interested in pursuing STEM education. Similarly, university high school relations personnell may find these results helpful in identifying and recruiting students likely to enroll and persist in a STEM discipline.

Recommendations for Future Research

1. Future studies should explore additional TTC graduating cohorts as they become available.
2. Future studies should evaluate other factors that differ among TTC pre-engineering students such as their home high school, TTC instructors, and optional course selection for later cohorts.
3. Future studies should evaluate the extent to which parental influence affects student choices to complete a pre-engineering course of study and to subsequently enroll in engineering at OSU.
4. Future studies of TTC students at other universities should be conducted. While a large plurality of TTC completers has attended OSU thus far, significant numbers of students have also attended the University of Oklahoma and Tulsa University. A similar study of persistence at those universities would provide some insight into the extensibility of these results.

5. Future studies should include a process for identifying students who originally did not self-identify OSU as their school of choice but ultimately enrolled there. Given the small population size and the fluidity of student choices these students could have a marked impact on the data.
6. A regional or national cooperative organization is needed to create and maintain a dataset that can be used for definitive quantitative research on the effect of pre-engineering coursework on persistence and performance in college.

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APPENDICES

Appendix A Institutional Review Board Approval Form

Oklahoma State University Institutional Review Board

Date:	Wednesday, March 30, 2016	Protocol Expires:	2/5/2017
IRB Application No:	ED146		
Proposal Title:	A Comparison of High School Pre-engineering Course-taking and Engineering Student Persistence and Degree Completion		
Reviewed and Processed as:	Exempt **Modification**		

Status Recommended by Reviewer(s) **Approved**

Principal Investigator(s):

Teddy Wyatt
12777 S 277th E Ave
Coweta, OK 74429

Mary Jo Self
261 Willard
Stillwater, OK 74078

The requested modification to this IRB protocol has been approved. Please note that the original expiration date of the protocol has not changed. The IRB office MUST be notified in writing when a project is complete. All approved projects are subject to monitoring by the IRB.

☒ 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.

The reviewer(s) had these comments:

Mod to add data from Tulsa Technology Center, add 75 subjects.

Signature :

Hugh Crethar, Chair, Institutional Review Board

Wednesday, March 30, 2016
Date

Appendix B Tulsa Technology Center Permission to Use Student Data

TulsaTech
.edu

P.O. Box 477200 Tulsa, OK 74147 918.828.5000

January 28, 2016

Mr. Teddy Wyatt
12777 South 277th East Ave.
Coweta, OK 74429-3303

Mr. Wyatt:

You are hereby authorized to use the student data requested in your letter dated November 2nd for your Master's Thesis research. Specifically, the student data from Tulsa Tech that you may use is as follows:

- Name (only for the purposes of matching with OSU student records)
- List of the pre-engineering courses completed by the student
- Grades in the pre-engineering courses completed by the student
- Year graduated from Tulsa Tech
- Attendance records

Regards,

Steve Tiger, Ph.D.
Superindent/CEO, Tulsa Tech

Administrative Offices
6111 E. Skelly Dr.
Tulsa, OK

Broken Arrow Campus
4000 W. Florence St.
Broken Arrow, OK

Owasso Campus
10800 N. 140th E. Ave
Owasso, OK

Peoria Campus
3850 N. Peoria Ave.
Tulsa, OK

Riverside Campus
801 E. 91 St.
Tulsa, OK

Sand Springs Campus
924 E. Charles Page Blvd.
Sand Springs, OK

Lemley Memorial Campus

Career Services Center
3420 S. Memorial Dr.
Tulsa, OK

Health Sciences Center
3350 S. Memorial Dr.
Tulsa, OK

Lemley Campus
3420 S. Memorial Dr.
Tulsa, OK

Training Center
3638 S. Memorial Dr.
Tulsa, OK

November 2, 2015

Tulsa Technology Center
P.O. Box 477200
Tulsa, OK 74147-7200

ATTN: Dr. Steve Tiger, Superintendent & CEO

Dear Dr. Tiger:

In partial fulfillment of the requirements for a Masters degree in Teaching, Learning and Leadership at Oklahoma State, I am proposing to write a thesis that explores whether students that complete a pre-engineering sequence exhibit a difference in persistence in engineering school. This is an expansion of a study that Dr. Belinda Cole published about three years ago. The College of Engineering Architecture and Technology is interested in the results of my proposal and I believe it would have value for Tulsa Tech as well.

I am requesting your permission to be able to use existing student data already available from the Tulsa Tech Pre-Engineering Academy. I will be obtaining an Institutional Research Board (IRB) approval from Oklahoma State using all of the institutional protocols necessary to protect human subjects while doing research.

The existing student data from Tulsa Tech that I am requesting to use is as follows:

- Name (used only to match them with the corresponding OSU student record. Once the match has been made, each student will be given a number and the document showing the name matched to the OSU student record will be destroyed.)
- List of the pre engineering courses completed
- Grades in the PLTW courses
- Year graduated from the Academy
- Attendance record

I will be working closely with Dr. Mary Jo Self as my adviser. My masters committee will be working with me as well as I make my research proposal this fall.

I propose actual data collection and analysis to begin upon receiving IRB approval and I anticipate completing the study during the Spring 2016 semester. The results of my study will be available for Tulsa Tech to use as well.

If you have any questions about this request, please contact me at teddy.wyatt@tulsatech.edu or by phone at 918.645.3494. I would appreciate your written approval to use the data requested for this research project.

Regards,

Teddy Wyatt

Cc: Dr. Mary Jo Self

VITA

Teddy Ray Wyatt

Candidate for the Degree of

Master of Science

Thesis: A STUDY ON THE PERSISTENCE OF OKLAHOMA STATE UNIVERSITY STUDENTS WHO COMPLETED A PRE-ENGINEERING PROGRAM AT TULSA TECHNOLOGY CENTER

Major Field: TEACHING, LEARNING AND LEADERSHIP

Biographical:

Education:

Completed the requirements for the Master of Science in Occupational Education at Oklahoma State University, Stillwater, Oklahoma in December, 2016.

Completed the requirements for the Bachelor of Science in Electrical and Computer Engineering at Oklahoma State University, Stillwater, Oklahoma in 1985.

Experience:
Tulsa Technology Center, Pre-Engineering Academy, Instructor, 2006-present
Brushfire Technologies, LLC, Founder and Managing Director, 2004-2006
Carrier Access Corporation, Vice President of Engineering, 2002-2004
Carrier Access Corporation, Director of Engineering, 2000-2002
TouchStar Technologies, Project Manager, *1999-2000*
Seiscor Technologies/Pulse Communications, Manager of Platform Development, 1996-1999
Frontier Engineering, Inc, engineering and management positions culminating in Aircraft Systems Business Area Manager, 1986-1996
United States Air Force, Cooperative Education Engineer, 1983-1985

Professional Memberships:
Senior Member of Institute of Electrical and Electronics Engineers, 1982-present, Chair of Tulsa Section 2004-2007
Member of Oklahoma Association for Career & Technology Education, 2006-present