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Engaging Community College Students Using an Engineering Learning Community

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ABSTRACT

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The study investigated whether community college engineering student success was tied to a learning community. Three separate data collection sources were utilized: surveys, interviews, and existing student records. Mann-Whitney tests were used to assess survey data, independent *t*-tests were used to examine pre-test data, and independent *t*-tests, analyses of covariance (ANCOVA), chi-square tests, and logistic regression were used to examine post-test data. The study found students that participated in the Engineering TLC program experienced a significant improvement in grade point values for one of the three post-test courses studied. In addition, the analysis revealed the odds of fall-to-spring retention were 5.02 times higher for students that participated in the Engineering TLC program, and the odds of graduating or transferring were 4.9 times higher for students that participated in the Engineering TLC program. However, when confounding variables were considered in the study (engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status), the analyses revealed no significant relationship between participation in the Engineering TLC program and course success, fall-to-spring retention, and graduation/transfer. Thus, the confounding variables provided alternative explanations for results. The Engineering TLC program was also found to be effective in providing mentoring opportunities, engagement and motivation opportunities, improved self confidence, and a sense of community. It is believed the Engineering TLC program can serve as a model for other

community college engineering programs, by striving to build a supportive environment, and provide guidance and encouragement throughout an engineering student's program of study.

This dissertation is dedicated to my wife, Susan, and my children, Nicholas, Taylor, and Ryan, for their support, love, and inspiration. I also dedicate this dissertation to my parents, for instilling a work ethic that has allowed me to realize my goals.

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I would like to thank my fellow doctoral students, Nancy Adam-Turner, Jason Barr, Christine Damrose-Mahlmann, Tom Hughes, Donna McCauley, Matt McGraw, and Stacy Waters-Bailey. This would have been a lonely journey without them.

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INTRODUCTION

There is a strong need to develop future engineers and technicians (Bracey, 2008). Burkhardt and Schoenfeld (2003) have argued that increasing the number of undergraduate students obtaining degrees in engineering and technology will provide a workforce that is prepared to ensure a healthy economy through technological advancements. The occupational outlook for engineers is favorable. Employment of engineers and technicians is expected to grow over the next decade with overall job opportunities expected to be good (U.S. Department of Labor, Bureau of Labor Statistics, 2014). The United States has approximately 1.6 million engineering jobs that pay $42 per hour in median wages (Wright, 2014). Every engineering occupation has experienced job growth, with an overall engineering job growth of seven percent (Wright, 2014). While the unemployment rate in the United States continues to hover around seven percent, it is less than two percent for engineers (Hicks, 2013). Therefore, there are strong needs and opportunities for future engineers. However, only half the students entering United States universities as engineering majors complete degree requirements (Pearson & Miller, 2012; Wulf & Fisher, 2002).

Background of the Study

Need for engineering graduates.

The U.S. has been an engineering and invention leader for almost two hundred years. Innovations pioneered in the Unites States include airplanes, light bulbs, transistors, integrated circuits, the telephone, and nuclear reactors (Hicks, 2013). While innovations have come from many countries, not one country has been as productive as the United States (Hicks, 2013). To remain productive, the United States needs to train a

new generation of engineers to create a vibrant future, just as preceding generations did (Vest, 2011). If the number of newly educated engineers is insufficient to fulfill employer needs, creativity and international competitiveness will be compromised (Bracey, 2008).

The graduation rate for engineering students in the United States is very low. A decade ago, over 40% of engineering students in U.S. universities did not complete the degree requirements (Wulf & Fisher, 2002). Today, only half of the engineering students entering U.S. four-year universities graduate (Pearson & Miller, 2012). These low graduation rates are due in part to a steady enrollment decrease in sciences and engineering (Barry, 2009). In addition, few students persist in engineering fields and many transfer to other college majors (Barry, 2009; Ohland et al., 2008).

One way to increase the number of engineering graduates is to embrace the pool of students pursuing engineering at community colleges (Sislin & Mattis, 2005). Community college students that complete an associate of science degree in engineering are just as likely to receive a bachelor's degree as students who attend four-year campuses only (Sislin & Mattis, 2005). In fact, 20% of engineering degree holders began their academic careers at community colleges (Sislin & Mattis, 2005). Hence, community colleges are essential to the education of engineers in the United States (Sislin & Mattis, 2005). However, poor completion rates are also found at community colleges. Roughly 90% of community college students enroll with intentions of earning a credential or to transfer to a four-year university, while only 39% earn a certificate, associate's degree, or bachelor's degree within six years (Hoachlander, Sikora, & Horn, 2003). Thus, while

engineering graduation rates at U.S. universities have been low, the graduation rates for engineering students at community colleges have been even lower.

Student readiness and success.

Student postsecondary attendance patterns have become complex, with nearly 60% of undergraduates attending more than one institution, and 35% of this group crossing state lines in the process (Adelman, 2006). One out of eight undergraduates based in four-year institutions use community colleges to fill in pieces of their curriculum (Adelman, 2006). This diverse group of postsecondary students requires a varied skillset to be successful in college. Some student readiness characteristics include academic intensity of the high school curriculum, participation in extracurricular activities, and student motivation. Adelman (2006) found that the single most important factor for college student success was the academic intensity of the high school curriculum. Specifically, the highest level of mathematics in high school was found to be a key marker in pre-collegiate momentum (Adelman, 2006). In addition, successful college students require both academic preparation and motivation (Kuh, Kinzie, Schuh, & Whitt, 2005). Motivation can be developed through participation in college extracurricular activities. Participation in extracurricular activities improves the overall college experience by promoting student involvement (Astin, 1993). Thus, students must be engaged and motivated to allow for successful student development.

Student development.

Students experience change during college. They often become more mature, knowledgeable, and focused (Pascarella & Terenzini, 2005). Student development and change can be supported by the college. Tinto (2003) found that five conditions promote

student development and persistence. These conditions were expectations, support, feedback, involvement, and learning. Students are more likely to persist and graduate in settings that expect them to succeed and that provide academic, social, and personal support (Tinto, 2003). Students are also more likely to persist and graduate in settings that provide frequent and early feedback about their performance (Tinto, 2003). Knowing what you know and don't know focuses student learning (Chickering & Ehrmann, 1996). Students must also feel valued as members of the institution (Tinto, 2003). The frequency and quality of contact with faculty, staff, and other students is an important part of student persistence (Tinto, 2003). Chickering and Ehrmann (1996) found that frequent student-faculty contact in and out of class was the most important factor in student motivation and involvement. Students who are actively involved in learning with others are more likely to persist in college (Tinto, 2003). Learning is enhanced when it is more like a team effort than a solo race (Chickering & Ehrmann, 1996). Thus, providing a collaborative and engaging environment improves student development and learning.

Interest in engineering.

There are several important qualities that are necessary to be a successful engineer. These qualities include creativity, and skills related to listening, mathematics, problem solving, writing, and communication (U.S. Department of Labor, Bureau of Labor Statistics, 2014). Studies have shown that students are receptive to engineering activities that are viewed as practical and purposeful (Bamforth, Crawford, Croft, & Robinson, 2005). Students that enjoy abstract thinking and a focus on correct and precise answers are often drawn to engineering (Bernold, Spurlin, & Anson, 2007). Hence, to

attract students to engineering, the profession must be presented as practical, highlight the use of abstract thinking, and enforce student confidence in mathematics and science.

In recent years, engineering education has witnessed a sharp increase in research related to academic success and persistence within engineering programs (French, Immekus, & Oakes, 2005). Several studies have attempted to identify variables that significantly predict success in engineering programs (French, Immekus, & Oakes, 2005). Some cognitive variables include Scholastic Aptitude Test (SAT) score, high school rank, grade point average (GPA), and mathematics course success rate (French, Immekus, & Oakes, 2005; Orth, 2004). Non-cognitive factors have also been identified to predict engineering student success. Some non-cognitive variables include age, gender, ethnicity, full-time/part-time status, socioeconomic status, confidence, presence of mentors, motivation, support, sense of community, and poor teaching (Cech, Rubineau, Silbey & Seron, 2011; Eris et al., 2010; Marra, Rodgers, Shen & Bogue, 2012; Min, Zhang, Long, Anderson & Ohland, 2011). Hence, successful indicators of engineering student success must consider both the cognitive and non-cognitive domains of student performance.

Institutional interventions.

To improve engineering student success, colleges have experimented with several institutional interventions. While each intervention has experienced varying results, some successful trends have been identified. These trends include providing a personal and collaborative learning environment, using tutors and peer reviews, replacing instruction with learning, and using project led education. These trends successfully address both cognitive and non-cognitive domains of student performance, and can be

incorporated into learning communities (Brown, Hansen-Brown, & Conte, 2011). Research has described the impressive benefits of small learning communities, including lower drop-out rates, increased graduation rates, and higher grade point averages (Fischer, Bol, & Pribesh, 2011). Attributes of successful learning communities include learning environments, teaching strategies, student engagement, and mentoring.

Learning communities.

Learning communities in four-year universities have been shown to effectively engage students. Learning community pedagogy promotes deep and meaningful learning (Brown, Hansen-Brown, & Conte, 2011). Nearly 90% of learning community students view themselves as part of a campus community, and over 91% say they feel a sense of belonging with the college (Laanan, Jackson, & Stebleton, 2013). Participation in learning communities has been linked to more positive student attitudes towards engineering and higher levels of student satisfaction with collaborative learning techniques (Doolen & Biddlecombe, 2014). Thus, undergraduate improvement efforts should include increasing the number of learning community opportunities, adapted to an institution's culture, mission, and student characteristics, to increase the chances of success for more students (Zhao & Kuh, 2004).

While engineering learning communities at four-year institutions have been found to be successful, few engineering learning communities exist in community colleges. Thus, this study bridges the gap in the literature by evaluating the impacts of a learning community on an engineering program at a northeastern community college.

Conceptual Framework

The conceptual framework for this study combined Astin’s (1999) Student Involvement Theory, Pascarella’s (1985) General Model for Assessing Change, and the Center for the Integration of Research, Teaching, and Learning's (CIRTL) learning community model (Pfund et al., 2012). According to Astin’s (1999) Student Involvement Theory, “the greater the student’s involvement in college, the greater will be the amount of learning and personal development” (p. 529). In addition, components of Pascarella’s General Model for Assessing Change (1985) were utilized. In Pascarella's model, change is a function of students' background characteristics, interactions with major socializing agents, and the quality of the student's efforts in learning and developing (Pascarella, 1985). Finally, the CIRTL's learning community model brings together groups of people for shared learning and the discovery and generation of knowledge (Pfund et al., 2012). Thus this study's conceptual framework sought to maximize student involvement to improve student development, encourage student interactions as socializing agents, and utilize shared learning and discovery (see Figure 1). Both cognitive and non-cognitive domains of student performance were acknowledged as indicators for engineering student success. These domains, in turn, were incorporated into an institutional intervention to improve the low graduation rates for engineers. Specifically, an engineering learning community was used to address cognitive domain indicators such as course success, retention, and graduation/transfer. In addition, an engineering learning community was used to address non-cognitive domain indicators such as mentoring, engagement and motivation, providing a sense of community, and instilling student confidence.

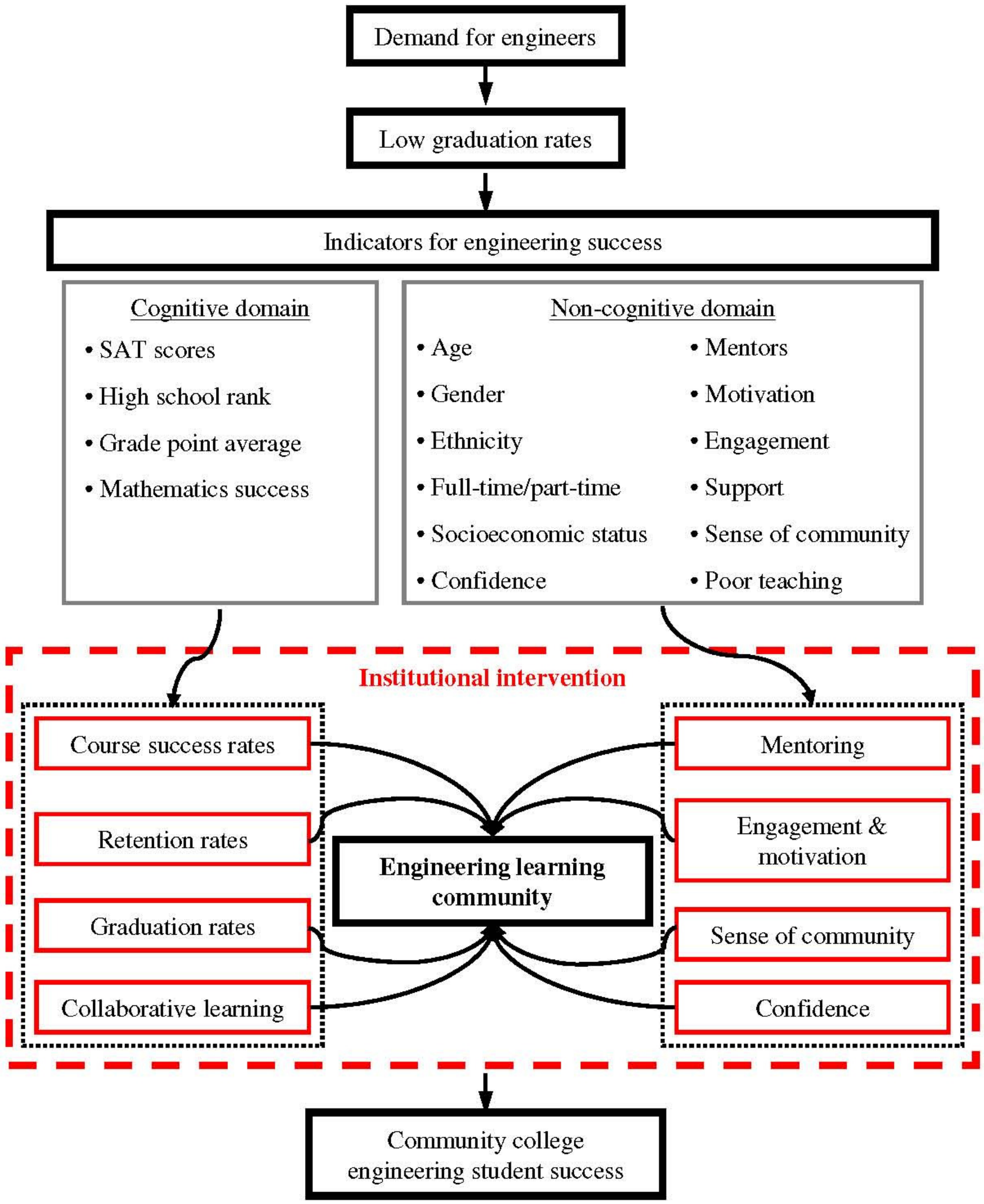

Figure 1. Conceptual framework for the relationship between an engineering learning community and student success

Purpose Statement and Research Questions

To investigate whether community college engineering student success was tied to a learning community, a pilot plan entitled "Engineering TLC: Tutors and Learning Communities" was implemented. Engineering TLC sought to establish mentoring

opportunities, increase course success rates, increase student retention, increase student engagement and motivation, provide a sense of community, and increase graduation rates. The purpose of this study was to investigate whether community college student success and engagement was tied to participation in an engineering learning community at a northeastern community college.

The following research questions were addressed in this study:

1. What is the relationship between course success and participation in the Engineering TLC program?

   1a. What is the relationship between course success and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

2. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program?

   2a. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

3. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program?

   3a. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

4. How effective is the Engineering TLC program in providing mentoring opportunities?
5. How effective is the Engineering TLC program in providing opportunities for student engagement and motivation?
6. How effective is the Engineering TLC program in providing a sense of community?

Significance of the Study

This study investigated whether community college student success and engagement was tied to participation in an engineering learning community at a northeastern community college. Student success included the assessment of course success, retention, and graduation/transfer. In addition, student success was assessed by considering goals related to establishing mentoring opportunities, increasing student engagement and motivation, and providing a sense of community. Thus, cognitive and non-cognitive domains of student performance are assessed. This study bridged the gap in the literature by evaluating the effectiveness of a learning community on an engineering program at a northeastern community college.

The results of the study also have implications for practice. If the Engineering TLC program was effective, then it could serve as a model for other community college engineering programs. With proper implementation, engineering student success at community colleges will improve, and may result in an increase in undergraduate students obtaining degrees in engineering. This will help provide a workforce that can ensure a healthy economy through technological advancements and maintain America's creativity and international competitiveness (Bracey, 2008; Schoenfeld, 2003).

Overview of the Methodology

This study utilized both quantitative and qualitative methods to assess student success and engagement in the Engineering TLC program. Course success, student retention, and graduation/transfer rates were evaluated using quantitative methods. Qualitative methods were used to assess goals related to establishing mentoring opportunities, increasing student engagement and motivation, and providing a sense of community. The sample for this study was comprised of students in both the engineering science and civil engineering technology programs at a northeastern community college.

A survey assessed student perceptions of Engineering TLC at three milestones: prior to joining the learning community, after one semester in the learning community, and after two semesters in the learning community. The same survey also assessed perceptions of the control group at the beginning of the first semester. Therefore the survey served as both a formative and summative measure.

At the conclusion of the program, student interviews were conducted. Selective sampling was used to allow consideration of gender and engineering major in the interview results. The survey investigated student perceptions involving presence of mentors, confidence, study group access, engagement and motivation, and peer relationships.

Course success, student retention, and graduation/transfer rates were evaluated using quantitative statistical methods as summative measures. Existing student records were used for the quantitative analyses. The research method used was the nonrandomized control group pretest-posttest design. The two groups were defined as

those students that participated in the Engineering TLC program and those that did not participate (the control group).

Delimitations

The study focused on an engineering learning community at a northeastern community college. The engineering learning community ran for one academic year. There were 93 full time engineering and engineering technology students at the college. Thirty-eight students participated in the Engineering TLC program, with the remaining students serving as the control group.

Composite pre-test scores were developed for each group by considering grade point values for: pre-calculus, Physics 1, and English 1. The analysis was confined to grade point values for identical courses taken prior to participation in the Engineering TLC program.

After participation in the Engineering TLC program, the study examined course success (grade point values), student retention, and graduation/transfer. The course success was confined to grade point values for identical courses taken after participation in the Engineering TLC program. Student retention was confined to fall-to-spring retention. This was then used to provide a benchmark to assess the college's ability to retain students. Since the program was only in effect for one academic year, retention between first and second years was not included in the study.

Graduation was confined to sophomore students in the Engineering TLC program that received a degree or certificate from the college. Transfer was confined to sophomore students in the Engineering TLC program that moved from a community college to a four-year institution of higher education.

Definition of Key Terms

The following definitions apply throughout this study:

- Cognitive domain: Area of study that deals with processes and measurable results, as related to engineering education.
- Community college: "A regionally accredited institution of higher education that offers the associate degree as its highest degree" (Vaughan, 2006, p. 2).
- Course success: Grade point value of students who receive a passing/satisfactory grade.
- Engineer: Professional requiring engineering education, training, and experience and the application of special knowledge of the mathematical, physical and engineering sciences to such services or creative work as consultation, investigation, evaluation, planning and design of engineering works and systems (New Jersey State Board of Professional Engineers and Land Surveyors, 2013).
- Graduation: Completion of an academic plan of study in engineering or engineering technology resulting in the award of a degree or certificate from a community college.
- Graduation rate: Percentage of students who graduate from either the engineering science or civil engineering technology program.
- Learning community: A small group of students characterized by a common sense of purpose used to build a sense of group identity, cohesiveness, and uniqueness; to encourage continuity and the integration of diverse curricular and co-curricular experiences; and to counteract the isolation that many students feel (Falls, 2009).
- Non-cognitive domain: Perception, judgment, and reasoning contrasted with

emotional processes, as related to engineering education.

- Retention: Fall-to-spring retention of engineering and engineering technology students participating in the Engineering TLC program for one academic year.
- Student success: Extent to which satisfactory or improved performance is observed in relation to course success, student retention, and graduation/transfer. Also the extent to which satisfaction is experienced by engineering students related to mentoring opportunities, student engagement and motivation, and a sense of community.
- Technician: A person who is a potential candidate for license as a professional engineer who is a graduate of an approved engineering technology curriculum from an accredited school or college (New Jersey State Board of Professional Engineers and Land Surveyors, 2013).
- Transfer: Movement from a community college to a four-year institution of higher education to pursue an undergraduate degree in engineering or engineering technology.
- Transfer rate: Percentage of students who move from either the engineering science or civil engineering technology program to a four-year institution of higher education to pursue an undergraduate degree in engineering or engineering technology.

Summary

Engineering is a field that seeks to understand and improve the world by developing high quality solutions to practical problems (Burkhardt & Schoenfeld, 2003). Engineering in the Unites States has a strong current demand and a favorable projected

employment outlook. However, engineering graduation rates at U.S. universities have been low, and graduation rates for engineering students at community colleges have been even lower (Bracey, 2008; Hoachlander, Sikora, & Horn, 2003; Wulf & Fisher, 2002). While engineering learning communities have been found to be an effective educational practice, few have been implemented in community colleges. This study bridges the gap in the literature by evaluating the effectiveness of a learning community on an engineering program at a northeastern community college.

In Chapter 2 a review of literature related to engineering student success is provided, including the need for engineering graduates, poor college graduation rates, student readiness and success, student development, and interest in engineering. Both cognitive and non-cognitive indicators for engineering student success are reviewed, along with institutional intervention options, including use of learning communities.

CHAPTER 2

LITERATURE REVIEW

Introduction

Employment of engineers and technicians is expected to grow over the next decade with overall job opportunities expected to be good (U.S. Department of Labor, Bureau of Labor Statistics, 2014). However, only half the students entering United States universities as engineering majors complete degree requirements (Pearson & Miller, 2012; Wulf & Fisher, 2002). This poor completion rate can also be found at community colleges (Hoachlander, Sikora, & Horn, 2003). Engineering and engineering technology programs at the northeastern community college currently have a combined enrollment of 93 students. However, in 2013, only 11 students graduated with either an Associate degree or a Certificate of Proficiency (Maccariella, 2014).

To address the poor completion rates in their engineering programs, a northeastern community college implemented a pilot plan entitled "Engineering TLC: Tutors and Learning Communities." This plan sought to establish mentoring opportunities, increase course success rates, increase student retention, increase student engagement and motivation, provide a sense of community, and increase graduation rates. The purpose of this study was to assess the impacts of implementing an Engineering TLC program on student success and engagement at a northeastern community college.

This chapter provides a review of the literature related to engineering student success. The review investigates the need for engineering graduates, poor college graduation rates, student readiness and success, student development, and interest in

engineering. Both cognitive and non-cognitive indicators for engineering student success are reviewed, along with institutional intervention options, including use of learning communities (see Figure 2).

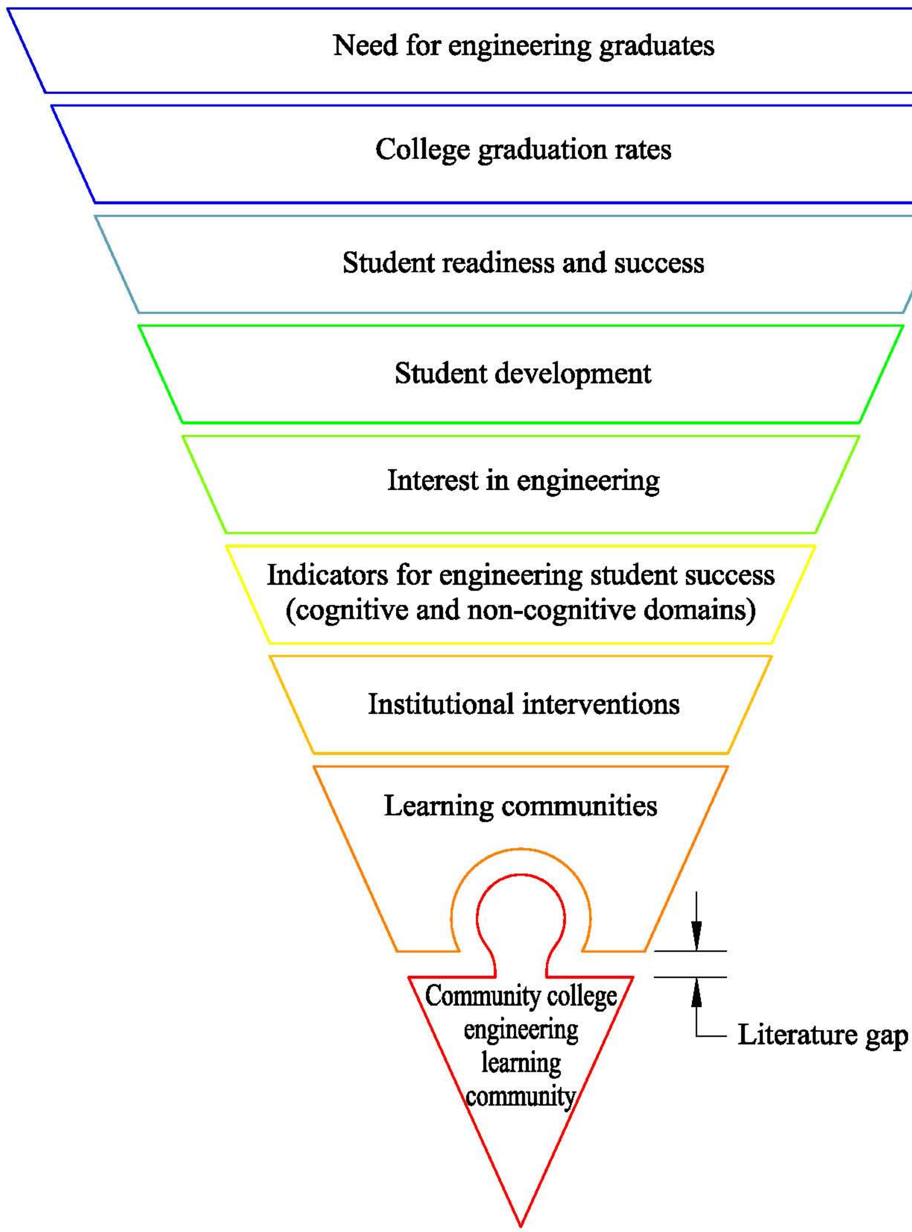

Figure 2. Literature review topic funnel diagram

Need for Engineering Graduates

Engineering is a field that seeks to understand and improve the world by developing high quality solutions to practical problems (Burkhardt & Schoenfeld, 2003). There is a strong need to develop future engineers and technicians. Burkhardt and Schoenfeld (2003) have argued that increasing the number of undergraduate students obtaining degrees in engineering and technology will provide a workforce that is prepared to ensure a healthy economy through technological advancements. There is a strong market demand for engineers. A study published in the December 2011 edition of Forbes magazine showed the job demand for engineers to be higher than all liberal arts majors (Hicks, 2013). In addition, while the unemployment rate in the United States continues to hover in the range of seven to eight percent, it is less than two percent for engineers (Hicks, 2013). The projected outlook for engineers is also favorable. Employment of engineers and technicians is expected to grow over the next decade with overall job opportunities expected to be good (U.S. Department of Labor, Bureau of Labor Statistics, 2014). Hence, engineering in the Unites States has a strong current demand and a favorable projected employment outlook.

The U.S. has been an engineering and invention leader for almost two hundred years. Innovations pioneered in the Unites States include airplanes, light bulbs, transistors, integrated circuits, the telephone, and nuclear reactors (Hicks, 2013). While innovations have come from many countries, not one country has been as productive as the United States (Hicks, 2013). If the number of newly educated engineers is insufficient to fulfill employer needs, creativity and international competitiveness will be compromised (Bracey, 2008).

College Graduation Rates

The graduation rate for engineering students in the United States is very low. A decade ago, over 40% of engineering students in U.S. universities did not complete the degree requirements (Wulf & Fisher, 2002). Today, only half of the engineering students entering U.S. universities graduate (Pearson & Miller, 2012). This poor completion rate can also be found at community colleges. Roughly 90% of community college students enroll with intentions of earning a credential or to transfer to a four-year university, while only 39% earn a certificate, associate's degree, or bachelor's degree within six years (Hoachlander, Sikora, & Horn, 2003). Engineering and engineering technology programs at the northeastern community college currently have a combined enrollment of 93 students. However, in 2013, only 11 students graduated with either an associate degree or a certificate of proficiency (Maccariella, 2014). Thus, while engineering graduation rates at U.S. universities have been low, the graduation rates for engineering students at community colleges have been even lower.

One potential reason for the poor completion rates at community colleges is that approximately two-thirds of all community college students attend primarily on a part-time basis (Berkner, Horn, & Clune, 2000). Therefore, it takes them longer to complete college degrees than the typical time expected. In addition, over 60% of community college students attend college while being employed (American Association of Community Colleges, 2014). As a result, graduation rates for engineering students at community colleges experience unique challenges related to the population that they serve.

Student Readiness and Success

Student postsecondary attendance patterns have become complex, with nearly 60% of undergraduates attending more than one institution, and 35% of this group crossing state lines in the process (Adelman, 2006). One out of eight undergraduates based in four-year institutions use community colleges to fill in pieces of their curriculum (Adelman, 2006). This diverse group of students requires a varied skillset to be successful in college. Some student readiness characteristics include academic intensity of the high school curriculum, participation in extracurricular activities, and student motivation.

Adelman (2006) found that the single most important factor for college student success was the academic intensity of the high school curriculum. Specifically, the highest level of mathematics in high school was found to be a key marker in pre-collegiate momentum (Adelman, 2006). Hoachlander, Sikora, and Horn (2003) reported that many community college students begin their postsecondary career with relatively low ability levels in mathematics. The level of high school mathematics required to be successful in college was courses above Algebra 2 (Adelman, 2006). However, students with a low socioeconomic status typically attend high schools that are much less likely to offer mathematics courses above Algebra 2 (Adelman, 2006). Thus, students with a high socioeconomic status are more likely to be ready to succeed in college. Colleges that intend to only admit the most talented and well prepared students, may be inadvertently limiting diversity by not admitting students with a low socioeconomic status (Kuh, Kinzie, Schuh, & Whitt, 2005).

Successful college students require both academic preparation and motivation (Kuh, Kinzie, Schuh, & Whitt, 2005). Motivation can be developed through participation in college extracurricular activities. Participation in extracurricular activities improves the overall college experience by promoting student involvement (Astin, 1993). Student involvement, in turn, has been found to improve both student self confidence and college retention (ACT, 2008). In fact, Nippert (2000) found that increased student involvement led to increased college persistence. Astin (1993) also found that increased attention to student motivation and behavior improved student success. In sum, student readiness includes a component unrelated to academic preparation. Students must be engaged and motivated to allow for successful student development.

Student Development

Students experience change during college. They often become more mature, knowledgeable, and focused (Pascarella & Terenzini, 2005). Not all of these changes are due to the college experience itself. Simple maturation, the pressure of seniors to reach closure, or the loss of the least able students may be an equally valid explanation of student change (Pascarella & Terenzini, 2005). However, student development and change can be supported by the college. Tinto (2003) found that five conditions promote student development and persistence. These conditions were expectations, support, feedback, involvement, and learning.

Students are more likely to persist and graduate in settings that expect them to succeed (Tinto, 2003). High expectations are a condition for student success. Tinto (2003) noted that, "No one rises to low expectations" (p.2). Students are affected by the expectations that faculty and staff hold for their individual performance. If a college

expects more, it will get it (Chickering & Ehrmann, 1996). Expecting students to perform well becomes a self-fulfilling prophecy (Chickering & Ehrmann, 1996). Hence student development is greatly impacted by the need for colleges to challenge their students.

Students are more likely to persist and graduate in settings that provide academic, social, and personal support (Tinto, 2003). Pascarella and Terenzini (2005) found that extracurricular and social involvement during college had a net positive impact on student development. Most students, especially those in their first year of college, required some form of support. Support must be readily available and connected to other parts of the student collegiate experience (Tinto, 2003). Students may not develop or persist in college if adequate support is not provided.

Students are more likely to persist and graduate in settings that provide frequent and early feedback about their performance (Tinto, 2003). Knowing what you know and don't know focuses student learning (Chickering & Ehrmann, 1996). Students need help in assessing their existing knowledge and competence. In classes, students need frequent opportunities to perform and receive feedback on their performance (Chickering & Ehrmann, 1996). Without prompt feedback, students won't be able to assess their competence level, and may not develop the skills necessary to be successful in college.

Students are more likely to persist and graduate in settings that involve them as valued members of the institution (Tinto, 2003). The frequency and quality of contact with faculty, staff, and other students is an important part of student persistence (Tinto, 2003). Chickering and Ehrmann (1996) found that frequent student-faculty contact in and out of class was the most important factor in student motivation and involvement.

Collaboration between faculty and students is essential to provide a valuable educational experience (Schwitzer, Ancis, & Brown, 2001). Colleges should focus on the needs of the whole learner (Clements, Harvey-Smith & James, 2005). Involvement matters, and at no point does it matter more than during the first year of college.

Students are more likely to persist and graduate in settings that foster learning (Tinto, 2003). Students who are actively involved in learning with others are more likely to persist in college (Tinto, 2003). Learning is enhanced when it is more like a team effort than a solo race (Chickering & Ehrmann, 1996). Good learning, like good work, is collaborative and social, not competitive and isolated (Chickering & Ehrmann, 1996). Clements, Harvey-Smith, and James (2005) found that interdisciplinary approaches to teaching improved learning outcomes. Pascarella and Terenzini (2005) found that cooperative or group learning experiences have a positive influence on self-reported growth including leadership abilities, and ability to work effectively in groups. Learning is not a spectator sport. Students do not learn much by sitting in classes listening to teachers and memorizing prepackaged assignments (Chickering & Ehrmann, 1996). They must talk about what they are learning, write reflectively about it, relate it to past experiences, and apply it to their daily lives (Chickering & Ehrmann, 1996). This agrees with Tinto (2003), who argues that we have to reshape our classrooms to provide powerful educational communities of engagement. Education professionals must humanize the classroom, acting as mediators, advisors, and learning environment managers (Schwitzer, Ancis, & Brown, 2001). Thus, providing a collaborative and engaging environment improves student learning.

Interest in Engineering

There are several important qualities that are necessary to be a successful engineer. These qualities include creativity, and skills related to listening, mathematics, problem solving, writing, and communication (U.S. Department of Labor, Bureau of Labor Statistics, 2014). A creative mind allows engineers to design and build equipment and machinery. Creativity allows for innovative solutions to complex problems. Engineers must share their creativity with other design professionals and be able to listen to input regarding various approaches to the design. Often the solutions to design problems require use of calculus, trigonometry and other advanced topics. Familiarity with mathematics topics allows for analysis, design and troubleshooting of projects. Projects also require consideration of many variables to evaluate and resolve complex problems. Therefore, engineering requires strong problem solving skills. Finally, the design concept must be clearly communicated to the project stakeholders, which requires strong writing and communication skills.

Studies have shown that students are receptive to engineering activities that are viewed as practical and purposeful (Bamforth, Crawford, Croft, & Robinson, 2005). Students that enjoy abstract thinking and a focus on correct and precise answers are often drawn to engineering (Bernold, Spurlin, & Anson, 2007). Confidence is another factor that influences interest in engineering. It has been shown that confidence predicts interest and persistence in engineering programs (Cech, Rubineau, Silbey, & Seron, 2011). Eris et al. (2010) found that confidence in mathematics and science influenced interest in engineering. Hence, to attract students to engineering, the profession must be presented as practical, highlight the use of abstract thinking, and enforce student confidence in

mathematics and science. Timing is also important. Li, Swaminathan, and Tang (2009) have argued that to effectively attract students to engineering, early exposure to the field is necessary.

Indicators for Engineering Student Success

In recent years, engineering education has witnessed a sharp increase in research related to academic success and persistence within engineering programs (French, Immekus, & Oakes, 2005). Several studies have attempted to identify variables that significantly predict success in engineering programs. Some cognitive variables include Scholastic Aptitude Test (SAT) score, high school rank, grade point average (GPA), and mathematics course success rate. Non-cognitive factors have also been identified to predict engineering student success. Some non-cognitive variables include age, gender, ethnicity, full-time/part-time status, socioeconomic status, confidence, presence of mentors, motivation, support, sense of community, and poor teaching.

Cognitive indicators.

SAT scores. French, Immekus, and Oakes (2005) found that SAT scores were significant in predicting engineering student success. This is consistent with results reported by Min, Zhang, Long, Anderson, and Ohland (2011), in which SAT scores were significantly related to survival rates for engineering students, with SAT math scores being a better predictor than SAT verbal scores. Nicholls, Wolfe, Besterfield-Sacre, Shuman and Larpkiattaworn (2007) also found SAT scores to be a significant measure of student success. Thus, engineering student success and survival is closely related SAT results.

High school rank. French, Immekus, and Oakes (2005) found that engineering student success is significantly related to high school rank. This is consistent with Veenstra, Dey, and Herrin (2008), who reported high school academic achievement as a significant pre-college characteristic for engineering student success. Thus, a history of academic success in high school is a powerful predictor of engineering college success. However, Nack (2007) found high school rank not to be a significant predictor for college student success. Nack reasoned that high school rank only established a percentile ranking for the high school graduating class. Thus, the student that earns the highest GPA would be ranked first in high school rank, even if that student's GPA was mediocre. For this reason, Nack reasoned, GPA is a better indicator for student success than high school rank.

Grade point average. French, Immekus, and Oakes (2005) found GPA to be a significant predictor for engineering survival. This agrees with Haemmerlie and Montgomery (2012), who found GPA to be significantly related to engineering persistence. Nicholls, Wolfe, Besterfield-Sacre, Shuman and Larpkiattaworn (2007) also found GPA to be a significant measure of student success. Orth (2004) found GPA to be a significant predictor for student success and program completion. Contrary to these studies, Veenstra, Dey, and Herrin (2009) found no significant relationship between GPA and engineering student retention. Thus, while results have been mixed, the general consensus is that GPA can be a significant predictor for engineering student success.

Mathematics course success rate. Mesa, Jaquette, and Finelli (2009) reported that mathematics course success rates were not significantly related to subsequent engineering courses success. This result differs from other research findings. For

example, Ohland, Yuhasz, and Sill (2004) found mathematics course success rates to be significantly related to engineering student retention. In addition, Tyson (2011) reported that engineering degree attainment was dependent upon achievement in mathematics courses. Veenstra, Dey, and Herrin (2008) found engineering success to be significantly related to mathematics knowledge and course success. Finally, Mau (2003) found the most significant predictor for persistence in engineering was mathematics success. Hence, the majority of studies have found that mathematics course success rates are significant predictors for engineering student success.

Non-cognitive indicators.

Age. Studies have been performed to determine if age impacts college student success. Wolfle (2012) found age was a significant factor for determining the success of college students. In fact, Wolfle found that an older nontraditional-age student was 136% more likely to succeed than a traditional-age student. Wolfle and Williams (2014) found that age was significantly related to both student success and persistence. While college success has been related to student age, course success has not. Reyes (2010) found that both younger and older student groups performed at a similar rate in a college mathematics course.

Gender. Gender has been shown to impact engineering student success. French, Immekus, and Oakes (2005) found that female engineering students generally have higher GPA's than males. Female engineering students also have a higher degree of intellectual curiosity (Haemmerlie & Montgomery, 2012). However, female students tend to leave engineering earlier than other populations (Min, Zhang, Long, Anderson, & Ohland, 2011). In addition, engineering has a low initial proportion of females (Ohland

et al., 2008). Thus, a program that begins with a low proportion of females, and experiences a high rate of female attrition results in a profession that is dominated by males. Beasley and Fischer (2012) found that the conventional engineering stereotype was instrumental in undermining the ambitions of female students from majoring in engineering fields. Mau (2003) argued that women may be concerned that if they are accepted by their male peers, they may lose their femininity. Hartman (2006) found that female students perceived conflicts between career and family responsibilities, and experienced discriminatory attitudes from teachers and the engineering community. To combat this, stronger efforts are needed to recruit and retain female scholars in engineering (Beasley & Fischer, 2012).

Ethnicity. The reputation of math, science, and engineering as hostile environments for minorities and the subsequent expectation of racism in these fields may provoke students to withdraw from engineering majors (Beasley & Fischer, 2012). There are high rates of attrition of minorities from engineering and an under-represented status in engineering graduate programs (Beasley & Fischer, 2012). In addition, ethnically diverse students have been found to be overrepresented in developmental education and have generally been found to be less successful in developmental courses than white students (Wolfle, 2012). Understanding the relationship between ethnicity and student success and persistence can help direct resources to create successful, welcoming engineering programs.

Full-time and part-time status. The typical community college student must balance the demands of family and work simultaneously (Wonacott, 2001). This often produces a student that works part-time while attending college. Approximately two-

thirds of all community college students attend primarily on a part-time basis (Berkner, Horn, & Clune, 2000). In addition, over 60% of community college students attend college while being employed (American Association of Community Colleges, 2014). Part-time enrollment in college often results in lower retention and student persistence (Forman, 2009). The more frequently students engage with faculty, staff, and their peers, the more likely students will persist (Tinto, 2003). Part-time enrollment limits the timeframe for this type of interaction. Hence, students enrolled in college on a part-time basis experience unique challenges related to engagement with faculty and their peers.

Socioeconomic status. Expanding access to engineering for underrepresented groups must consider the needs of socioeconomic disadvantaged students. Low-income students are disadvantaged with regard to high school completion, college matriculation, and postsecondary outcomes (Lundy-Wagner et al., 2014). Postsecondary students' individual socioeconomic backgrounds and institution-level characteristics both play an important role in postsecondary matriculation. Not only do less-privileged students matriculate to four-year institutions at lower rates, but they also tend to enroll in less selective institutions that often enroll more low-income and disadvantaged students (Lundy-Wagner et al., 2014). Low-income students consistently perform less well in college, have lower academic aspirations, and are less likely to progress in math and science courses than students who come from families with higher incomes (Lundy-Wagner et al., 2014). The level of high school mathematics required to be successful in college are courses above Algebra 2 (Adelman, 2006). However, students with a low socioeconomic status typically attend high schools that are much less likely to offer mathematics courses above Algebra 2 (Adelman, 2006). Thus, students with a low

socioeconomic status are less likely to be ready to succeed in college. Colleges that intend to only admit the most talented and well prepared students, may be inadvertently limiting diversity by not admitting students with a low socioeconomic status (Kuh, Kinzie, Schuh, & Whitt, 2005).

Confidence. Professional role confidence refers to one's ability to fulfill the expected roles, and identity features of a successful professional field (Cech, Rubineau, Silbey, & Seron, 2011). Becoming a successful professional involves not just the mastery of the core intellectual skills of the profession, but also the cultivation of confidence in the profession (Cech, Rubineau, Silbey, & Seron, 2011). Students that leave engineering in good academic standing typically report low confidence in engineering and science skills (Eris et al., 2010). Confidence in an engineering career often begins while in high school. Hartman (2006) found that support for an engineering career is the foundation for student confidence. In particular, support from parents and friends is significant. Female students are generally less confident to pursue engineering, and student confidence is generally lowest during freshman year (Eris et al., 2010; Hartman, 2006). It has been demonstrated that mentor involvement increases student motivation to study engineering, and improves student confidence (Eris et al., 2010). Hence, improving student confidence can improve interest and persistence in engineering. Mentoring should be employed to develop student confidence; and freshman and females should be targeted to improve confidence.

Mentors. There is evidence that mentor influence is a strong motivator for students to study engineering (Eris et al., 2010). Mentor influence has been found to have a positive effect on student persistence (Eris et al., 2010). Non-persisting students

are typically motivated by parents, whereas persisting students are more motivated by mentors (Eris et al., 2010). Personal interaction with faculty members strengthens students' connections to the college and helps them focus on academic progress (Community College Survey of Student Engagement, 2006a). Working with an instructor on a project allows students to experience how experts identify and solve practical problems. Through such interactions, faculty members become role models, mentors, and guides for continuous, lifelong learning (Community College Survey of Student Engagement, 2006a). As expected, contact between students and faculty mentors increases during the four years of college (Kuh & Hu, 2001). Faculty seem to make themselves more accessible to juniors and seniors, and find it more rewarding to work with more intellectually mature students (Kuh & Hu, 2001). Hence, mentors improve student persistence and interest in engineering, and provide positive role models. Mentors must resist the temptation to be more accessible to juniors and seniors, and make every effort to continuously engage freshman engineering students.

Motivation and engagement. Motivation and engagement has been shown to significantly improve student success. Motivation should not be underestimated, as it has been found to be strongly correlated with persistence in engineering (Nicholls, Wolfe, Besterfield-Sacre, Shuman, & Larpkiattaworn, 2007). Motivation can drive success despite poor academic preparation (Martin, Galentino, & Townsend, 2014). Dweck and Leggett (1988) found motivated and engaged students were able to view challenges as opportunities to learn something new. To motivate and engage students, faculty must focus on the students' individual interests (Renninger, 2000). Individual interest increases as knowledge and the perceived value of the subject increases (Renninger,

2000). In fact, it is individual interest that sustains attention and student effort (Renninger, 2000). Individual interest drives motivation and is the most evident theme demonstrated by college graduates (Martin, Galentino, & Townsend, 2014). While many college graduates find motivation to achieve from within, some find motivation from their family or college. Hence, motivation and engagement improves student success and persistence, and can drive success despite poor academic preparation. Colleges must maintain motivation and engagement by focusing on individual student interests.

Support. Community college students benefit from support services targeted to assist them with academic and career planning, academic skill development, and other areas that affect learning and retention (Community College Survey of Student Engagement, 2006b). Thus, engineering schools should promote a more interactive and supportive academic and social environment to provide a strong sense of belonging (Li, Swaminathan, & Tang, 2009). However, support systems must be utilized to be effective. While 74% of students report that their college puts a large emphasis on providing the support they need, 32% of students rarely or never use them (Community College Survey of Student Engagement, 2006b). In addition, most college student support services come from career centers; thus students are not being guided by those with engineering backgrounds or expertise (Lichtenstein et al., 2009). This lack of support from engineering faculty can result in a reduced sense of community and belonging (Marra, Rodgers, Shen, & Bogue, 2012). Hence, while engineering students benefit from support services, the services must be led by engineering faculty, and effectively utilized by the students to provide a supportive academic environment.

Sense of community. As the number of students interested in engineering shrinks, colleges struggle to attract and retain students (Falls, 2009). To do so, colleges attempt to devise strategies that are effective to recruit, retain, and graduate more students. Some colleges have proposed that faculty and student services create an appropriate campus culture to promote student success (Falls, 2009). This culture must provide an inclusive student sense of community. It has been shown that an increased sense of community results from co-curricular activities (Falls, 2009). In particular, students working together towards a common goal, such as completing a design project, experienced an increased sense of community. This academic system interaction improves faculty interaction and builds a cohort community of engineering students. An open and caring environment is also critical to establishing a sense of community (Cheng, 2004). Such an environment promotes social system interaction and removes the feeling of student loneliness (Cheng, 2004). Working together as a cohort encourages students to work together outside of class on academic issues and increases a sense of community within their environment (Falls, 2009). Specifically, it has been recommended that academic and student service professionals develop communities where students are treated as individuals and feel cared for by both their peers and their advisors (Falls, 2009). Hence, providing a college culture that focuses on an engineering sense of community improves interaction, builds a cohort, and removes the feeling of loneliness.

Poor teaching. Better preparation for the engineering workforce calls for a reform of engineering education (Li, Swaminathan, & Tang, 2009). This reform demands actions in engineering colleges including improving teaching methods and practices (Li, Swaminathan, & Tang, 2009). Colleges must realize that students with different learning

styles tend to respond differently to various teaching approaches (Li, Swaminathan, & Tang, 2009). Bernold, Spurlin, and Anson (2007) found that individual learning styles and compatibility with faculty teaching styles were related to program persistence. Marra, Rodgers, Shen, and Bogue (2012) found that poor teaching contributed to students' decisions to leave engineering. In fact, as many as 35% of engineering students experienced some degree of poor teaching (Marra, Rodgers, Shen, & Bogue, 2012). New ways of structuring and delivering engineering courses must be developed since existing paradigms do not prepare students for a workplace that is multicultural and demands interdisciplinary teamwork and collaboration (Arms, Duerden, Green, Killingsworth, & Taylor, 1998). Engineering professors must be willing to commit to new teaching methods to provide intellectual growth and perspective for both them and their students (Arms, Duerden, Green, Killingsworth, & Taylor, 1998). Improved teaching must also consider the unique challenges facing part-time engineering professors. Part-time college professors tend to experience a lack of institutional engagement and meaningful teaching assessments (Jolley, Cross, & Bryant, 2014). In fact, the extent to which a college relies on part-time faculty members is often considered to be reflective of the degree of commitment to instruction. This is illustrated by the fact that some regional accrediting agencies require institutions to address the proportion of faculty members employed on a part-time basis as a component of reaffirmation of accreditation (Charlier & Williams, 2011). Thus, engineering teaching methods must address multiple student learning styles, and provide interdisciplinary collaborative assignments. In addition, colleges must provide a high degree of commitment to teaching, by implementing effective training and assessment for part-time faculty.

Institutional Interventions

To improve teaching and learning, and improve indicators for engineering student success, colleges have experimented with several institutional interventions. While each intervention has experienced varying results, some successful trends have been identified. These trends include providing a personal and collaborative learning environment, using tutors and peer reviews, replacing instruction with learning, using project led education, using learning communities, and improving faculty development.

Community colleges offer open admission and affordable higher education that meets the needs of the continually evolving population that it serves (Hachey, Conway, & Wladis, 2013). As such, community colleges experience a large population of under-represented groups. These under-represented groups often require additional remedial courses and experience low graduation rates (Bailey, Calcagno, Jenkins, Kienzl, & Leinbach, 2005). Changing demographics, burgeoning technologies, and a faltering public education system have led to increased illiteracy (Roueche & Roueche, 1999). To address this, many colleges have adopted a more collaborative approach for at-risk students (Bailey, Calcagno, Jenkins, Kienzl, & Leinbach, 2005). The benefits of a collaborative approach are improved self-esteem, a safe learning environment, and better classroom success rates (Jenkins, Antil, Wayne, & Vadasy, 2003). In addition, a collaborative approach provides a greater student voice and improved classroom participation (Jenkins, Antil, Wayne, & Vadasy, 2003). The collaborative approach strives to provide a personal learning environment. Colleges have noted that institution size is negatively correlated with successful student outcomes (Bailey, Calcagno, Jenkins, Kienzl, & Leinbach, 2005). Students graduate at higher rates in smaller community

colleges, indicating that such institutions provide a more personalized environment (Bailey, Calcagno, Jenkins, Kienzl, & Leinbach, 2005). The personal learning environment should encourage collaborative, non-competitive assignments, to improve student self-esteem and confidence (Bourdon & Carducci, 2002). Hence, a personal and collaborative learning environment has been found to be effective in improving student participation and success.

Utilization of tutors and peer reviews has also been found to be effective in improving student success. Bourdon and Carducci (2002) found students who received peer mentoring earned higher grades, and re-enrolled and graduated at higher rates than students that did not receive peer mentoring. In addition, Hendriksen and Yang (2005) found tutored students achieved higher grade point averages, course passing rates, course completion rates, and short-term retention. Small group tutorials led by more advanced students have been used as part of an effective learning program, with both tutors and tutees benefitting from the experience (Nisbet, Haw, & Fletcher, 2014). Engineering tutoring typically stresses an understanding of the problem, rather than the correct answer (Nisbet, Haw, & Fletcher, 2014). Effective tutors must demonstrate strong communication skills to effectively explain engineering problems simply and directly (Nisbet, Haw, & Fletcher, 2014). Nisbet, Haw, and Fletcher (2014) have indicated all students should be offered the opportunity to participate in small tutor groups, but that social as well as academic qualifications of the tutors should be considered, with appropriate training provided where necessary.

Colleges are also finding that learning should be stressed in lieu of instruction. In the instruction paradigm, faculty are conceived primarily as disciplinary experts who

impart knowledge by lecturing (Barr & Tagg, 1995). The learning paradigm, on the other hand, conceives of faculty as primarily the designers of learning environments; they study and apply best methods for producing learning and student success (Barr & Tagg, 1995). Colleges are now realizing that their mission is not instruction but rather that of producing learning with every student by whatever means is most appropriate (Barr & Tagg, 1995). Barr and Tagg (1995) conclude by stating:

> The change that is required to address today's challenges is not vast or difficult or expensive. It is a small thing. But it is a small change that changes everything. Simply ask, how would we do things differently if we put learning first? Then do it (p. 17).

Use of project led instruction in engineering has been found to be effective in improving student success. This process increases the applicability of engineering curricula to 'real life' situations, and has been found to increase student retention (Bourdon & Carducci, 2002). The concept for project led instruction is to employ a project method of teaching that encourages students to select and complete a project revolving around engineering concepts (Bourdon & Carducci, 2002). Professors act more as helpers and facilitators rather than lecturers. The essence of this method of instruction is that students solve open-ended assignments for which the solutions are not yet known. They do this by gathering the necessary knowledge and skills in inter-disciplinary teams (Weenk & Van Der Blij, 2011). Project led instruction is consistent with constructivism and inductive teaching methods (Weenk & Van Der Blij, 2011). Research findings support the assertion that project led instruction enhances effectiveness and efficiency of student learning (Weenk & Van Der Blij, 2011). Hence, project led

instruction improves student success by increasing the applicability of engineering using 'real life' projects and inter-disciplinary teams.

Community college learning communities have been found to improve student success. Learning communities typically organize instruction around themes, with students progressing as cohorts (Bailey, 2005). Learning communities are designed to provide more coherent and engaging experiences than traditional courses, and give students and faculty more opportunities for increased intellectual interaction and shared inquiry (Bailey, 2005). Community college students involved in learning communities earn higher grades, persist at higher rates, and are more satisfied with the collegiate experience than students enrolled in traditional courses (Bourdon & Carducci, 2002). In addition, learning communities tend to enhance peer and faculty interaction, and promote a greater sense of academic community between students and faculty (Bourdon & Carducci, 2002). The learning community model is particularly interesting for community colleges because it is one way that these commuter institutions can engage with their students in a more intensive way than normally occurs in the classroom (Bailey, 2005). In fact, many community colleges have adopted various forms of learning communities as a strategy to forge stronger links with the diverse and fragmented community college student body (Bailey, 2005). Learning communities promote persistence by facilitating the creation of supportive peer groups among students, encouraging shared learning, and giving students the opportunity to actively participate in knowledge creation (Bailey, 2005).

Faculty development has been shown to enhance instructional quality (Bourdon & Carducci, 2002). Student success is inextricably linked to great teaching in community

colleges (Bourdon & Carducci, 2002). However, implementing new teaching and learning methods require a specific set of skills and competencies (Smith, 2005). Faculty cannot be expected to know intuitively how to design and deliver course content in a new format (Smith, 2005). Research says most teachers teach as they were taught (Smith, 2005). However, educators lack a model or benchmark for new and innovative teaching methods (Smith, 2005). This may be why 58% of faculty members described themselves as more fearful than excited about the growth of new teaching approaches (Kolowich, 2012). In some cases, the pressure for rapid development of new educational measures has resulted in resistance from faculty (Liu, 2012). Part of this resistance may be because institutions typically do not offer adequate training (Liu, 2012). Hachey, Conway, and Wladis (2012) found that faculty typically receive insufficient training, particularly related to technological advances. Faculty also struggle with how best to harness advanced technologies for maximum pedagogical effect in courses and programs (Amirault, 2012). Faculty want control of course content, but experience pressure to constantly revise courses, implement new methodological approaches, and remain in what is essentially a constant state of personal training and skills development (Amirault, 2012). For this reason, it is important for faculty to share best practices (Hachey, Conway, & Wladis, 2013). Naidu (2014) found that sharing results of effective teaching was paramount to course success. Hence, faculty must urge their colleges to provide adequate training, and collaborate to share best practices.

In summary, institutional intervention as defined as the implementation of new and innovative ways to improve student learning, is necessary. A collaborative and personal approach to learning improves student self-esteem and participation;

engineering tutors and peer reviews stress an understanding of the problem rather than a correct answer; and student learning is more important than instruction. In addition, project led instruction increases the applicability of engineering using 'real life' projects and inter-disciplinary teams, and learning communities promote persistence by facilitating the creation of peer groups and encouraging shared learning. Faculty training is necessary to develop competencies with these new teaching approaches.

Learning Communities

New and innovative ways to improve teaching and learning must provide a collaborative and personal approach, stress problem understanding rather than a correct answer, and focus on student learning rather than instruction. Real life projects and interdisciplinary teams create peer groups and encourage shared learning. All these features can be incorporated into learning communities (Brown, Hansen-Brown, & Conte, 2011) (see Figure 3). Research has described the impressive benefits of small learning communities, including lower drop-out rates, increased graduation rates, and higher grade point averages (Fischer, Bol, & Pribesh, 2011). Attributes of successful learning communities include learning environments, teaching strategies, student engagement, and mentoring.

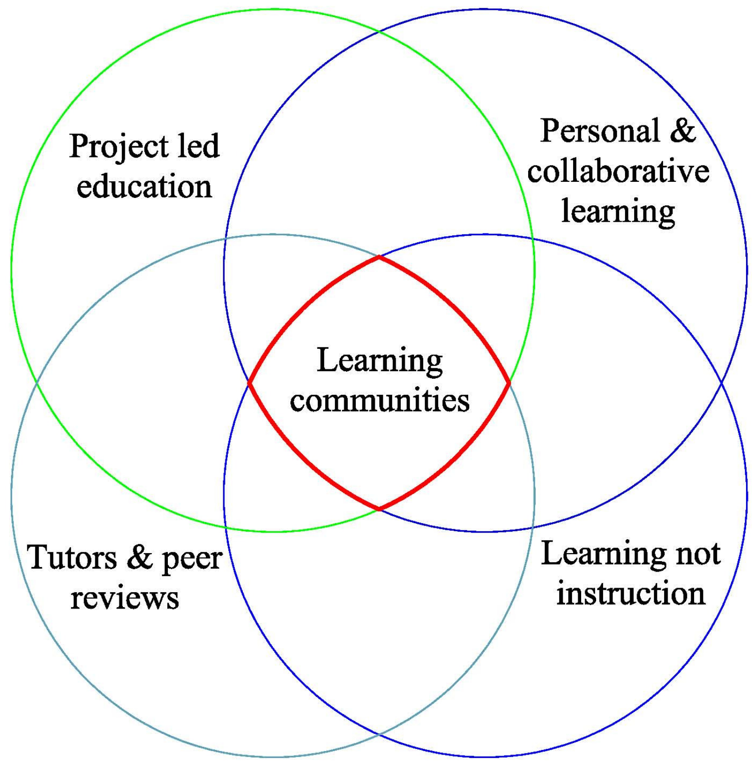

Figure 3. Learning community Venn diagram

In higher education, lecturing is the least effective learning environment to use to create a positive learning environment (Brown, Hansen-Brown, & Conte, 2011). However, lecturing still is the preferred teaching strategy by most faculty (Brown, Hansen-Brown, & Conte, 2011). Thus Brown, Hansen-Brown, and Conte (2011) have noted that "the sage on the stage will be gradually replaced by the guide on the side" (p. 44). Today, faculty must proactively lead small groups, by providing continuous input and reinforcement (Budny, Paul, & Newborg, 2010). Students that participate in learning communities expect focused attention (Laanan, Jackson, & Stebleton, 2013). A benefit to this style of instruction is that shy students can more easily be engaged, as they are frequently less likely to participate or volunteer in a traditional classroom setting (Raitman, Hamadi, & Zhou, 2004). As faculty reinforce student contributions, they inject

their own knowledge, and confirm student understanding, resulting in an effective learning community (Shea, 2006). Learning communities can engage students that typically view college as daunting and lonely (Wasburn & Miller, 2004). The learning community can further build a sense of group identity, cohesiveness, and uniqueness (Wasburn & Miller, 2004). For engineering students, teamwork and communication are the most important skills necessary for success; both of which are stressed in learning communities (Arms, Duerden, Green, Killingsworth, & Taylor, 1998). Thus, the environment of a learning community must minimize the use of traditional lectures, provide continuous input and reinforcement, promote group identity and cohesiveness, and stress teamwork and communication.

Learning communities require a unique teaching strategy. Brown, Hansen-Brown, and Conte (2011) found that visual stimulation, structured learning, authentic learning activities, and community activities were necessary for successful learning communities. Budny, Paul, and Newborg (2010) found hands-on opportunities reinforce a positive attitude towards the course content. In general, directed facilitation by the instructor contributes most to an effective learning community (Shea, 2006). Engineering learning communities stress team projects, teamwork, communication, sustainability, and consideration of global/societal design context (Borrego, Karlin, McNair, & Beddoes, 2013). Learning communities seek to engage students while building trust and team effort (Borrego, Karlin, McNair, & Beddoes, 2013). It has been shown that students learn best, retain more, and function more successfully when their teachers employ active and collaborative learning techniques (Arms, Duerden, Green, Killingsworth, & Taylor, 1998). Thus, an effective learning community teaching strategy

must utilize directed facilitation to provide visual stimulation, hands-on assignments, authentic learning activities, and collaborative learning techniques.

Learning communities have been shown to effectively engage students. Learning community pedagogy promotes deep and meaningful learning (Brown, Hansen-Brown, & Conte, 2011). Nearly 90% of learning community students view themselves as part of a campus community, and over 91% say they feel a sense of belonging with the college (Laanan, Jackson, & Stebleton, 2013). Participation in learning communities has been linked to more positive student attitudes towards engineering and higher levels of student satisfaction with collaborative learning techniques (Doolen & Biddlecombe, 2014). While authentic student-faculty relationships can take time to develop, the learning community's environment accelerates this relationship and builds a supportive classroom environment (Jackson, Stebleton, & Laanan, 2013). To effectively engage students, faculty must provide immediate and ongoing student support (Budny, Paul, & Newborg, 2010). Faculty must provide direction and creative insight and stress student individual accountability (Raitman, Hamadi, & Zhou, 2004). The experience of working with others reinforces skills necessary for a professional engineering career (Szelényi, Denson, & Inkelas, 2013). Students develop teamwork skills gradually in a mutually supportive atmosphere so they can enter the workforce prepared for the professional world (Arms, Duerden, Green, Killingsworth, & Taylor, 1998). Hence, learning communities engage students, provide deep and meaningful learning opportunities, accelerate the faculty-student relationship, and stress individual accountability.

Faculty mentors play a vital role in the success of a learning community. In fact, the single-most important factor identified in students' degree attainment was a positive

mentoring experience (Brown, Hansen-Brown, & Conte, 2011). Faculty must create a friendly environment in which students can feel free to express their feelings and concerns while receiving academic and extracurricular support and information, in an informal setting (Budny, Paul, & Newborg, 2010). Faculty serving as mentors must have the ability to listen, be respectful of diversity, and be willing to exchange constructive feedback with students, staff, and faculty (Budny, Paul, & Newborg, 2010). Faculty mentors can be an authentic source of encouragement to allow relationships to develop (Jackson, 2013). Students have reported that faculty mentors encouraged them to become engaged both academically and socially, which created a bond between the student and the institution (Laanan, Jackson, & Stebleton, 2013). In fact, it has been shown that frequent interaction with faculty mentors is the strongest predictor for student success (Lundberg, 2014). Participation in learning communities allows faculty to generate empathy for students, build authentic relationships, engage in the larger campus community, and collaborate with other faculty members (Jackson, Stebleton, & Laanan, 2013). Students have reported that positive student-faculty relationships were a key to the success of the learning communities (Arms, Duerden, Green, Killingsworth, & Taylor, 1998). Thus, faculty mentors must provide academic and extracurricular support in an informal setting to create a bond between the student and the college. This interaction has been shown to be the strongest predictor for student success, and the key to a successful learning community.

In summary, the environment of a learning community must minimize the use of traditional lectures, and stress teamwork and communication. An effective learning community teaching strategy must provide visual stimulation, hands-on assignments, and

collaborative learning techniques. Learning communities must engage students, to accelerate the faculty-student relationship, and stress individual accountability. Finally, faculty mentors must provide academic and extracurricular support in an informal setting to create a bond between the student and the college. Learning communities are an effective educational practice (Zhao & Kuh, 2004). Thus, undergraduate improvement efforts should include increasing the number of learning community opportunities, adapted to an institution's culture, mission, and student characteristics, to increase the chances of success for more students (Zhao & Kuh, 2004).

Summary

The review of the literature indicates that there is a strong market demand for engineers and a favorable projected employment outlook. However, the graduation rate for engineering students in the United States is very low. If the number of newly educated engineers is insufficient to fulfill employer needs, creativity and international competitiveness will be compromised. While engineering graduation rates at U.S. universities have been low, the graduation rates for engineering students at community colleges have been even lower.

Some readiness characteristics for community college students include academic intensity of the high school curriculum, participation in extracurricular activities, and student motivation. Hence, student readiness includes a component unrelated to academic preparation. Students must be engaged and motivated to allow for successful student development. Student development and change can be supported by the college, and high expectations are a condition for student success. Students may not develop or persist in college if adequate support is not provided.

Involvement matters, and at no point does it matter more than during the first year of college. Learning is enhanced when it is more like a team effort than a solo race. There are several important qualities that are necessary to be a successful engineer. These qualities include creativity, and skills related to listening, mathematics, problem solving, writing, and communication. Hence, to attract students to engineering, the profession must be presented as practical, highlight the use of abstract thinking, and enforce student confidence in mathematics and science.

Both cognitive and non-cognitive variables have been shown to predict engineering success. Some cognitive variables include Scholastic Aptitude Test (SAT) score, high school rank, grade point average (GPA), and mathematics course success rate. Some non-cognitive variables include age, gender, ethnicity, full-time/part-time status, socioeconomic status, confidence, presence of mentors, motivation, support, sense of community, and poor teaching. Thus both cognitive and non-cognitive domains of student performance must be acknowledged as indicators for engineering student success.

Engineering is dominated by males since the program begins with a low proportion of females, and experiences a high rate of female attrition. To combat this, stronger efforts are needed to recruit and retain female scholars in engineering. In addition, understanding the relationship between ethnicity and student success and persistence can help direct resources to create successful, welcoming engineering programs. Also, students enrolled in college on a part-time basis experience unique challenges related to engagement with faculty and their peers.

Mentors improve student persistence and interest in engineering, and provide positive role models. Motivation and engagement improves student success and

persistence, and can drive success despite poor academic preparation. Colleges must maintain motivation and engagement by focusing on individual student interests.

Providing a college culture that focuses on an engineering sense of community improves interaction, builds a cohort, and removes the feeling of loneliness. Engineering teaching methods must address multiple student learning styles, and provide interdisciplinary collaborative assignments. In addition, colleges must provide a high degree of commitment to teaching, by implementing effective training and assessment for part-time faculty.

Institutional intervention, as defined as the implementation of new and innovative ways to improve student learning, is necessary. A collaborative and personal approach to learning improves student self-esteem and participation; engineering tutors and peer reviews stress an understanding of the problem rather than a correct answer; and student learning is more important than instruction. In addition, project led instruction increases the applicability of engineering using 'real life' projects and inter-disciplinary teams, and learning communities promote persistence by facilitating the creation of peer groups and encouraging shared learning. Faculty training is necessary to develop competencies with these new teaching approaches.

The environment of a learning community must minimize the use of traditional lectures, and stress teamwork and communication. An effective learning community teaching strategy must provide visual stimulation, hands-on assignments, and collaborative learning techniques. Learning communities must engage students, to accelerate the faculty-student relationship, and stress individual accountability. Faculty

mentors must provide academic and extracurricular support in an informal setting to create a bond between the student and the college.

Learning communities are an effective educational practice. Thus, undergraduate improvement efforts should include increasing the number of learning community opportunities, adapted to an institution's culture, mission, and student characteristics, to increase the chances of success for more students.

Engineering learning communities should be implemented to improve graduation rates and meet the strong demand for engineers. Engineering learning communities must engage and motivate students in a collaborative and supportive atmosphere by accelerating the faculty-student relationship. Learning should be stressed rather than instruction. Finally, under-represented groups must be recruited and retained. While these needs have been clearly documented in the literature, very few engineering learning communities exist in community colleges. Thus, this study bridged the gap in the literature by evaluating the impacts of a learning community on a community college engineering program.

A northeastern community college implemented a pilot plan entitled "Engineering TLC: Tutors and Learning Communities." This plan sought to establish mentoring opportunities, increase course success, increase student retention, increase student engagement and motivation, provide a sense of community, and increase graduation/transfer rates. The purpose of this study was to assess the impacts of implementing an Engineering TLC program on student success and engagement at a northeastern community college.

The following research questions were addressed in this study:

1. What is the relationship between course success and participation in the Engineering TLC program?

    1a. What is the relationship between course success and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

2. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program?

    2a. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

3. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program?

    3a. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

4. How effective is the Engineering TLC program in providing mentoring opportunities?

5. How effective is the Engineering TLC program in providing opportunities for student engagement and motivation?

6. How effective is the Engineering TLC program in providing a sense of community?

CHAPTER 3

METHODOLOGY

There is a strong need to develop future engineers and technicians. Burkhardt and Schoenfeld (2003) have argued that increasing the number of undergraduate students obtaining degrees in engineering and technology will provide a workforce that is prepared to ensure a healthy economy through technological advancements. The occupational outlook for engineers is favorable. Employment of engineers and technicians is expected to grow over the next decade with overall job opportunities expected to be good (U.S. Department of Labor, Bureau of Labor Statistics, 2014). While there are strong needs and opportunities for future engineers, only half the students entering United States universities as engineering majors complete degree requirements (Pearson & Miller, 2012; Wulf & Fisher, 2002). This poor completion rate can also be found at community colleges. Data indicate that although roughly 90% of community college students enroll with intentions of earning a credential or to transfer to a four-year university, only 39% had earned a certificate, associate's degree, or bachelor's degree within six years (Hoachlander, Sikora, & Horn, 2003).

To address the poor completion rates experienced in engineering programs, colleges have experimented with several institutional interventions. While each intervention has experienced varying results, some successful trends have been identified. These trends include providing a personal and collaborative learning environment, using tutors and peer reviews, replacing instruction with learning, and using project led education. All these trends can be incorporated into learning communities (Brown, Hansen-Brown, & Conte, 2011). Research has described the impressive benefits of small

learning communities, including lower drop-out rates, increased graduation rates, and higher grade point averages (Fischer, Bol, & Pribesh, 2011). Attributes of successful learning communities include learning environments, teaching strategies, student engagement, and mentoring.

The purpose of this study was to assess the effects of implementing an engineering learning community on student success and engagement at a northeastern community college. A learning community pilot program was implemented at a northeastern community college entitled "Engineering TLC: Tutors and Learning Communities." This plan sought to establish mentoring opportunities, increase course success, increase student retention, increase student engagement and motivation, provide a sense of community, and increase graduation/transfer rates. This chapter includes the following sections: (1) research questions, (2) research design, (3) population and sample, (4) instrumentation, (5) data collection, (6) data analysis, and (7) limitations.

Research Questions

The following research questions were addressed in this study:

1. What is the relationship between course success and participation in the Engineering TLC program?

    1a. What is the relationship between course success and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

2. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program?

2a. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

3. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program?

3a. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

4. How effective is the Engineering TLC program in providing mentoring opportunities?
5. How effective is the Engineering TLC program in providing opportunities for student engagement and motivation?
6. How effective is the Engineering TLC program in providing a sense of community?

Research Design

The poor completion rates of engineering students in the United States has prompted a sharp increase in research aimed at the outcomes of academic success and persistence within engineering programs (Zhang, Anderson, Ohland, & Thorndyke, 2004). These studies sometimes result in inconsistent conclusions, which is troubling because institutional policy is often developed based on study results (Wolf, Harrington, Clark, & Miller, 2013). Identification and use of student success indicators can facilitate more intelligent use of data to encourage adjustment of resources to support students

(Supovitz, Foley, & Mishook, 2012). To that end, it is important to identify the most appropriate research design method to identify indicators for engineering student success.

Many research design and data analysis methods have been applied to analyze engineering student success (Li, Swaminathan, & Tang, 2009). Pre-experimental designs commonly used are either a one-shot experimental case study, or a one group pretest-posttest design (Li, Swaminathan, & Tang, 2009). As indicated in Table 1, quasi-experimental designs are commonly either a nonrandomized control group pretest-posttest design, or a simple time-series experiment (Li, Swaminathan, & Tang, 2009).

Table 1
Commonly Used Research Designs

Pre-Experimental Designs	Goal of Research
One-shot experimental case study	Show that a treatment precedes an event
One group pretest-posttest design	Show that change occurs after a treatment
Quasi-Experimental Designs	Goal of Research
Nonrandomized control group pretest-posttest design	Show that two groups are equivalent prior to treatment, and a change occurs after treatment
Simple time-series experiment	Show that change occurs over a lengthy period after a treatment

Adapted from P.D. Leedy and J.E. Ormrod, 2013, *Practical research: Planning and design*. Copyright 2013 by Pearson Education Inc.

Each of these pre-experimental and quasi-experimental designs have limitations (see Table 2). The one-shot experimental case study has a low internal validity because it does not demonstrate a cause and effect relationship. The one group pretest-posttest design identifies a change, but yields no conclusive results about the cause of the change.

A limitation of the simple time-series design is that some other event may cause change over time other than the treatment. Although other possible explanations cannot be ruled out for the non-randomized control group pretest-posttest design, some alternative explanations can be eliminated, which provides improved validity over other research design method.

Table 2
Limitations of Research Designs

Pre-Experimental Designs	Limitation
One-shot experimental case study	No cause and effect relationship
One group pretest-posttest design	No conclusive results about the cause of a change
Quasi-Experimental Designs	Limitation
Nonrandomized control group pretest-posttest design	Some alternative explanations can be eliminated
Simple time-series experiment	Findings may not be the result of the treatment

Adapted from P.D. Leedy and J.E. Ormrod, 2013, *Practical research: Planning and design*. Copyright 2013 by Pearson Education Inc.

Using an appropriate research design method allows a researcher to pursue the relevant rather than the measurable (Black, 1994). That is, a researcher would like to consider many possible factors that might influence a phenomenon and then attempt to control for all factors except those that are the focus of the investigation. Controlling factors is important to provide internal validity, which is the extent to which the design allows for legitimate conclusions (Leedy & Ormrod, 2013).

If random assignment of sample groups is impractical, a quasi-experimental design should be used (Leedy & Ormrod, 2013). Specifically, the most appropriate research design method to investigate engineering student success is the nonrandomized control group pretest-posttest design (see Figure 4). The nonrandomized control group pretest-posttest design can demonstrate that two groups are equivalent with respect to the dependent variables prior to treatment, thus eliminating initial group differences as an explanation for post-treatment differences. While other possible explanations for the results cannot be ruled out, some alternative explanations can be eliminated.

Time (t) →

		t_1 Measure	t_2 Treatment	t_3 Measure
Non-randomly Assigned	Group A (The Experimental Group)	$M_{A_{t_1}}$	T_x	$M_{A_{t_3}}$
	Group B (The Control Group)	$M_{B_{t_1}}$	-No-	$M_{B_{t_3}}$

Figure 4. Quasi-experimental design (nonrandomized control group pre-test, post-test). Adapted from P.D. Leedy and J.E. Ormrod, 2013, *Practical research: Planning and design*. Copyright 2013 by Pearson Education Inc.

The experimental group for this study was those students that participated in the Engineering TLC program, while the control group was those students that did not participate in the program. The Engineering TLC program was in effect for one academic year.

This study utilized both quantitative and qualitative methods to assess student success and engagement in the Engineering TLC program. Course success, student retention, and graduation/transfer rates were evaluated using quantitative methods. The remaining engagement goals were evaluated using qualitative methods.

For the qualitative portion of this study, the research tradition selected was a phenomenological design. A phenomenological design is used to understand an experience from the participant's point of view. A phenomenological design focuses on a particular phenomenon experienced by the participants (Leedy & Ormrod, 2013), such as engineering student's participation in the Engineering TLC program. Therefore, a phenomenological design was well suited for this study. The Engineering TLC logic map is shown in Appendix A, and the project's goals, objectives, and measures are illustrated in Table 3.

Table 3
Project Goals, Objectives, and Measures

Goals	Objectives	Measures
1. Establish mentoring opportunities	1.1 Develop an industry internship opportunity	1.1M Record the number of internship opportunities created
	1.2 Have students attend engineering conferences	1.2M Record the number of conferences attended
2. Increase course success rates	2.1 Increase student passing grades	2.1M Evaluate student passing grades compared to the control group
	2.2 Increase student's grade point averages	2.2M Evaluate student grade point averages compared to the control group
3. Increase student retention	3.1 Increase enrollment from fall to spring	3.1M Evaluate the change in enrollment compared to prior years
4. Increase student engagement and motivation	4.1 Provide educational field trips	4.1M Record the number of field trips
		4.1Ma Assess student engagement from field trips (surveys and interviews)
	4.2 Provide guest speakers to present project case studies	4.2M Record the number of guest speakers
		4.2Ma Assess student motivation from case studies (surveys and interviews)
	4.3 Develop a student chapter of the National Society of Professional Engineers (NSPE)	4.3M Verify that a student chapter was created
		4.3Ma Assess student's sense of community from the student chapter (surveys and interviews)
5. Provide a sense of community	5.1 Provide weekly learning communities and study sessions	5.1M Record attendance at the meetings and sessions
		5.1Ma Assess student's sense of community (surveys and interviews)
6. Increase graduation rates	6.1 Increase graduation rates	6.1M Evaluate change in graduation rates compared to the control group

Inputs included engineering faculty, student tutors, a learning community proctor, professional engineering societies, the industry advisory board, and the college's learning center. Outputs included providing engineering tutors, creating learning communities, creating mentoring opportunities, establishing peer relationships, developing internship opportunities, attending engineering conferences, taking field trips, presenting project case studies, and developing a student chapter of the National Society of Professional Engineers.

Population and Sample

The study population encompassed engineering students in the United States. This included students at community colleges that offer programs in engineering and civil engineering technology. The majority of civil engineering students are males (78%) (Gibbons, 2009). Demographic information for the population of civil engineering students in the United States indicate that 67% of students are white, 12% of students are Asian-American, 8.5% of students are Hispanic, and 4.2% of students are African-American (Gibbons, 2009). The population of engineering students in the nation is 81,382, which is the result of a steady enrollment decrease in sciences and engineering (Barry, 2009; National Center for Education Statistics, 2012).

The sample for this study was comprised of students in both the engineering science and civil engineering technology programs at a northeastern community college. Engineering science and civil engineering technology are separate but closely related programs. The engineering science program focuses on theory and conceptual design, while the civil engineering technology program focuses on application and implementation (ABET, 2011). The majority of the northeastern community college

sample engineering students (84%) were males. Demographic information for the sample of community college engineering students indicated that 67% of students are white, 8% of students are Asian-Pacific Islander, 8% of students are Hispanic, and 8% of students are African-American. All engineering and engineering technology students were invited to participate in the Engineering TLC program. Students were invited via email, visits to their classrooms, and discussions during advisement sessions (see Appendix B for recruitment material). All participants were 18 years of age or older.

The sample was suitable for this study since the demographic information was representative of the population. Also, the topic studied (the impacts of implementing an Engineering TLC program on student success and engagement) could be applied to the population of engineering students in the United States.

There were 93 full time engineering and engineering technology students at the community college. Thirty-eight students chose to participate in the Engineering TLC program, with the remaining students serving as the control group. Thus, a sample size of 93 students produced a confidence interval of 10.16%, for a confidence level of 95% and a population of 81,382 engineering students (Creative Research Systems, 2012). This sample size was large enough to conduct appropriate statistical analysis.

Instrumentation

This study utilized both surveys and interviews to assess three project goals:

1. Establish mentoring opportunities
2. Increase student engagement and motivation
3. Provide a sense of community

Surveys

A researcher designed survey assessed student perceptions of Engineering TLC at three milestones: prior to joining the learning community, after one semester in the learning community, and after two semesters in the learning community. The same survey also assessed perceptions of the control group at the beginning of the first semester. Thus, the first survey assessed whether the control group and the treatment group were similar prior to treatment, while the second survey assessed treatment group changes after one semester in the learning community. Therefore the survey served as both a formative and summative measure. All members of the Engineering TLC were asked to participate in the project surveys. The same survey was used at each milestone, to detect response changes over time. The survey investigated student perceptions involving presence of mentors, confidence, study group access, engagement and motivation, and peer relationships (see Appendix D). The theoretical blueprint for the surveys is shown in Appendix C.

To assess student perceptions of the Engineering TLC program, Likert scale questions were used. Five ordered response levels were used for each question. This scale measured the positive or negative responses to each question. These results were used to both compare the treatment group to the control group, and the variation of treatment group responses over time.

Demographic information was collected as part of the survey instrument. This provided a breakdown of response data into meaningful groups of respondents. The demographic information was used to both compare the treatment group to the control group, and the sample to the population. Demographic information collected included

age, gender, ethnicity, full-time or part-time student status, Pell grant participation, and high school attended (measure of wealth). Demographic information has been linked to persistence and graduation rates in engineering programs. For example, female students tend to leave engineering earlier than other populations (Min, Zhang, Long, Anderson, & Ohland, 2011). Also, there are high rates of attrition of minorities from engineering (Beasley & Fischer, 2012). Part-time enrollment in college often results in lower retention and student persistence (Forman, 2009). Finally, students with a low socioeconomic status are less likely to be ready to succeed in college (Kuh, Kinzie, Schuh, & Whitt, 2005).

The survey concluded with two open ended questions. The open ended questions gave the respondent an opportunity to provide a range of answers that may not have been initially considered. This allowed for more depth and insight into student perception of the Engineering TLC program. The open ended questions inquired why students chose to join the program and how the program could be improved to meet their needs (see Appendix I).

Instrument validity refers to the degree to which inferences can legitimately be made from the instruments in a study to the theoretical constructs on which those instruments were based (Agarwal, 2011). To accomplish instrument construct validity, experienced researchers in the field were consulted to discuss the wording of each item in the survey. The instrument was then revised based on the feedback collected. In addition, a pilot test was used to assess the survey. This allowed for identification of weaknesses within the survey and necessary revisions prior to implementation of the survey. The pilot test was conducted by five recent engineering graduates.

Interviews

At the conclusion of the year-long engineering learning community, eleven student interviews were conducted; seven treatment group interviews, and four control group interviews. Selective sampling was used to allow consideration of gender and engineering major in the interview results. The survey investigated student perceptions involving presence of mentors, confidence, study group access, engagement and motivation, and peer relationships. The theoretical blueprint for the interviews is shown in Appendix E. The interview protocol was as follows:

1. Please describe how the Engineering TLC program affected your access to engineering mentors?
2. Please describe how the Engineering TLC program affected your access to study groups?
3. Please describe how the Engineering TLC program affected your engagement and motivation?
4. Please describe how the field trips affected your engagement and motivation?
5. Please describe how the Engineering TLC program affected your student relationships?
6. Please describe how the student chapter of the engineering society affected your student relationships?

The interviews provided an opportunity to give voice to students participating in the Engineering TLC program using in-depth observations and one-on-one interviews. Semi-structured interview questions were used. The study had a specific topic in mind and a limited number of questions had been prepared in advance. Follow-up questions

were used to better assess and understand the interviewee responses. Separate interviews were conducted for each student. The same interview protocol was used for each student. The interviews sought rich and detailed information, not yes-or-no responses. The study looked for examples of experiences, narratives, and stories. The questions were open-ended, in that the interviewees could respond any way they choose, elaborating upon answers and raising new issues (Rubin & Rubin, 2011). The interview concluded by asking the student if there was anything that should have been asked that wasn't. This allowed students to elaborate on topics discussed and raise new issues. Students were given an opportunity to review the transcribed interviews and provide feedback. This allowed for an opportunity for further explanation.

The interviews were conducted in the engineering laboratory after a student's regularly scheduled class. Access to the room was readily available since there were no classes scheduled at the time, and the program coordinator approved use of the classroom. A large table in the back of the engineering laboratory was used for the interviews (see Figure 5). No other students or faculty were present for the interview. The large laboratory was quiet, with the room's heating system being just loud enough to serve as white noise and muffle occasional outside noise from the hallway, since the door was half open.

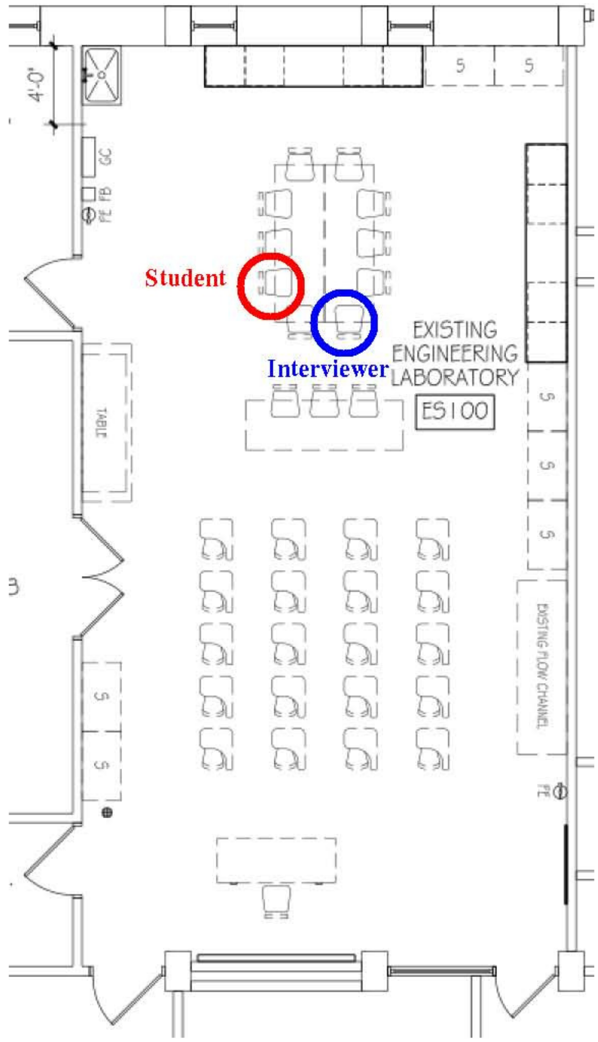

Figure 5. Engineering Laboratory Layout

Since the interviewer was also an engineering faculty member at the community college, the interviewer and student knew each other. Interviewer bias was considered as the interviewer may have subconsciously given subtle clues, with body language, or voice tone, that influenced the student into giving answers that were skewed towards the interviewer's own opinions, prejudices or values. Response bias, where subjects consciously or subconsciously give responses they think the interviewer want to hear, was considered. To address this, the amount of information given to the student was

restricted, to prevent them from understanding the full extent of the research. Inter-rater reliability was used to improve interpretation consistency. The transcribed interviews were reviewed by another community college professor to identify agreement regarding patterns and concepts that emerged. This bracketing verification removed interviewer personal beliefs and knowledge from the study. Bracketing was used as a means to demonstrate validity of the data collection and analysis process.

A pilot test was used to assess the interview questions. This allowed identification of flaws, limitations, or other weaknesses within the interview and for necessary revisions prior to implementation of the study. The pilot test was conducted by five recent engineering graduates. These graduates recommended that the pilot interview questions be revised to ask, "Please describe how..." rather than, "Can you describe…" The graduates found themselves answering the pilot questions as, "Yes" or "No," which did not allow patterns or concepts to emerge.

Strategies that enhanced the credibility of this study were member checking, persistent observation, and triangulation. Member checking is the ongoing consultation with participants to test the developing findings (Hays & Singh, 2011). Persistent observation was achieved by engaging in several data collections with a participant (Hays & Singh, 2011). Triangulation of data sources involves including several participant voices (Hays & Singh, 2011). This project studied multiple students using multiple data sources.

Data Collection

This study utilized three separate data collection sources: surveys, interviews, and existing student records. The surveys were administered at three milestones: prior to

joining the learning community, after one semester in the learning community, and after two semesters in the learning community. At the conclusion of the program, eleven student interviews were conducted; seven treatment group interviews, and four control group interviews. Finally, existing data was used to assess course success, retention, and graduation/transfer rates at the conclusion of the program.

Surveys

Survey information was collected using online questionnaires (see Appendix D). The surveys were sent via email to all 93 engineering students. The participants for this study were comprised of students in both the engineering science and civil engineering technology programs at a northeastern community college. All students that participated in the Engineering TLC program were required to complete the surveys, while those students not participating (the control group) were asked to complete the surveys. Surveys were administered at three milestones: prior to joining the learning community, after one semester in the learning community, and after two semesters in the learning community.

Students were invited to participate in the Engineering TLC program via email, visits to their classrooms, and discussions during advisement sessions. Appendix B includes the recruitment materials used. There were 93 full time engineering students at the college. Thirty-eight students participated in the Engineering TLC program, with the remaining students serving as the control group. All participants were 18 years of age or older.

Survey responses were anonymous and confidential. The results were aggregated and any identifying information was removed.

Interviews

At the conclusion of the year-long engineering learning community, eleven students were interviewed; seven from the treatment group, and four from the control group. Selective sampling was used to allow consideration of gender and engineering major in the interview results. The interviews were conducted in the college's engineering laboratory after the student's regularly scheduled class. Students were interviewed individually, with no other students or faculty present for the interview. All participants were 18 years of age or older. After approval by the student, an audio recorder was used to assist with data collection. Only the interviewer and the faculty supervisor had access to the interview results.

Participation in the interview was voluntary. Information gathered in this study was confidential. A pseudonym was used to provide anonymity. Students had the right to review and comment on information prior to the study's completion.

Existing Student Records

Course success, student retention, and graduation/transfer rates were evaluated using quantitative statistical methods as summative measures. The information required to complete the statistical analysis was obtained from the community college's office of Institutional Research, Assessment and Planning. Existing data was anonymous and confidential. The results were aggregated and any identifying information was removed.

Human Subjects Research Protections

Old Dominion University's Darden College of Education Human Subjects Review Committee has reviewed and approved three separate applications for this study related to exempt research that involves human subjects. Exempt research is intended to expedite

research with human subjects that presents minimal or no risk to participants. Appendix J contains the three applications that have been approved for exemption category 6.2 (for surveys and interviews) and exemption category 6.4 (for the existing student records).

Human Subjects Training

In preparation for this study, the researcher completed human subjects training as administered by the Collaborative Institutional Training Initiative (CITI) (see Appendix K). The training required satisfactory passing scores in the following modules: students in research, ethical principles, research with human subjects, regulations, assessing risk, informed consent, privacy and confidentiality, and conflicts of interest in research involving human subjects.

Data Management

To ensure ongoing and long-term security of the data generated by this project, a complete copy of materials was generated and stored independently on secure primary and backup sources (as data were generated). Materials were de-identified and converted to a searchable pdf document format. Electronic data was saved on a device that had the appropriate security safeguards such as unique identification of authorized users, password protection, encryption, automated operating, anti-virus controls, firewall configuration, and scheduled and automatic backups to protect against data loss or theft.

Five years after the project is completed, the data will be destroyed using hard disk degaussing. This process exposes the hard disk to a fluctuating magnetic field to reset the disk to a factory state. Older drives undergoing a hard disk degaussing will leave the disk in a factory state as if no file were present; while modern drives will be destroyed.

Risks and Benefits for Participants

The main potential benefit of this study is that the results could generate indicators for engineering student success. Therefore, if an indicator (or group of indicators) imply that the student will not have success, the college could intervene to recommend measures to address the indicator. The possible harm or risk resulting from this research is low. One risk would be adding anxiety to students that are told that their indicators put them at risk of not being successful in the program. Students would have to be reassured that the results of the research indicators may be statistically significant, but not proof of program success.

Data Analysis

Surveys

Likert response items were used to assess the majority of the questions on the survey. This measures the extent to which respondents agree or disagree with a particular question or statement. Five ordered response levels were used. After the questionnaire was completed, each item was analyzed separately.

The response categories in Likert items have a rank order, but the intervals between values cannot be presumed equal (Jamieson, 2004). Therefore, the measures of central tendency that are appropriate for ordinal data are median and mode, rather than mean and standard deviation (Jamieson, 2004). While it has become common practice to assume that Likert categories constitute interval level measurements, it has been argued that doing so would be like stating the average of 'fair' and 'good' is 'fair-and-a-half;' which is not true (Jamieson, 2004).

Therefore, this study treated the Likert responses as ordinal data, and reported the findings as bar charts, and tables with median and mode. The remaining demographic and open-ended information collected was reported using frequency plots and tables.

Survey data was used to both compare the treatment group to the control group, and the variation of treatment group responses over time. Therefore, the research method employed was the nonrandomized control group pretest-posttest design. The initial and final survey results from the Engineering TLC participants and control group participants were compared to demonstrate that the two groups were equivalent with respect to the dependent variables prior to treatment, thus eliminating initial group differences as an explanation for post-treatment differences.

Interviews

The interview information was analyzed using the six phases of data analysis outlined by Marshall and Rossman (1999): generating categories, themes, and patterns; coding the data; testing the emergent understandings; searching for alternative explanations; and writing the report. The data were organized through multiple readings of the text, including field notes, observations, and reflections. The text was reviewed to identify patterns and concepts. For the coding phase, examples were identified and coded to represent the core categories. Open coding was used, in that the collected data was divided into segments and then scrutinized for commonalities that could reflect categories or themes. Open coding allowed a reduction of data into a small set of themes that appeared to describe the phenomenon. When continued review produced no new descriptive values, categories were defined as sufficiently well-represented, or 'saturated' (Meyer & Schwitzer, 1999).

Inter-rater reliability was used improve interpretation consistency. The transcribed interviews were reviewed by another community college professor to identify agreement regarding patterns and concepts that emerged. The other college professor serves in a separate division than the author, and is of equal rank to the author, thus there were no power issues regarding reporting structure between the two reviewers. Thus, bracketing was used as a means to demonstrate validity of the data collection and analysis process.

The results of the interview were presented as evidence that warranted each claim. Claims were illustrated with concrete examples such as interview quotes and the descriptions of the context in which they occurred (Hays & Singh, 2011). An interpretive commentary was provided to allow a deeper understanding of the claims, including how the patterns occurred; the context in which they occurred; how they support or challenge the theory; and what alternative claims were considered (Hays & Singh, 2011).

Existing Student Records

As stated previously, the research method employed was the nonrandomized control group pretest-posttest design. The two groups were defined as those students that participated in the Engineering TLC program and those that did not participate (the control group). Composite pre-test scores were developed for each group by considering grade point values for: pre-calculus, English 1, and Physics 1. The goal was to show that the two groups were equivalent prior to the treatment (participation in the Engineering TLC program). The independent variable (Engineering TLC participation) had a nominal measurement scale, and the dependent variables (grade point values) had interval measurement scales. Therefore, the appropriate analysis method for the pre-test

assessment was an independent *t*-test (see Table 4). The data was investigated for potential outliers. The dependent variable was first converted to z-scores. A z-score is a number that results from the transformation of a raw score into units of standard deviation (Sprintall, 2012). A z-score of 3.29 constitutes an outlier (Field, 2009). Therefore, the absolute value of any z-score found to exceed 3.29 was considered to be an outlier, and was suppressed from the analysis. The dependent variable was then tested for normality. If the dependent variable was found to deviate from normality, a data transformation was employed to attempt to achieve normality. An independent *t*-test was performed to determine whether there was a statistically significant difference in the pretest scores for the two groups.

Table 4
Data Analysis Method Used to Assess Pre-test Scores

Independent Variable	Measurement Scale	Dependent Variable	Measurement Scale	Analysis Method
Engineering TLC program participation (Yes/No)	Nominal (Categorical)	Grade point Value (0.0-4.0)	Interval (Continuous)	Independent *t*-test

The two groups were then compared after the treatment by examining subsequent course success rates (grade point values), student retention, and graduation/transfer rates. For this study, graduation and transfer were considered as a single variable because community college students have the ability to move to a four-year institution of higher education with or without a degree or certificate from a community college. The goal was to show post-treatment differences while eliminating initial group differences as an explanation. The independent variable (Engineering TLC participation) had a nominal

measurement scale, and the dependent variables (retention and graduation/transfer) had nominal measurement scales. Therefore, the appropriate analysis method was a Chi square test (see Table 5). The Chi square test makes no assumptions regarding either the population mean or the shape of the underlying distribution, thus it is a nonparametric test (Sprintall, 2012). The Chi squire test provided a statistical test of significance between Engineering TLC participation and each of the dependent variables (retention rate and graduation/transfer).

The posttest assessment of grade point values had interval measurement scale. Therefore, the appropriate analyses methods for post-test assessment of grade point values was an independent *t*-test (see Table 5). The data was investigated for potential outliers. The dependent variable was converted to z-scores, and the absolute value of any z-score found to exceed 3.29 was considered to be an outlier, and was suppressed from the analysis. The dependent variable was then tested for normality. If the dependent variable was found to deviate from normality, a data transformation was employed to attempt to achieve normality. An independent *t*-test was performed to determine whether there was a statistically significant difference in the posttest grade point values for the two groups.

Table 5
Data Analysis Method Used to Assess Post-test Scores

Independent Variable	Measurement Scale	Dependent Variable	Measurement Scale	Analysis Method(s)
Engineering TLC program participation (Yes/No)	Nominal (Categorical)	Grade point value (0.0-4.0)	Interval (Continuous)	Independent *t*-test
		Retention (enrolled/not enrolled)	Nominal (Categorical)	Chi-square test and Logistic Regression
		Graduation / Transfer (Yes/No)	Nominal (Categorical)	Chi-square test and Logistic Regression

The two groups were then compared after the treatment by examining subsequent course success rates (grade point values), student retention, and graduation/transfer rates, along with several confounding variables. The confounding variables considered were engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time student. Therefore, the appropriate analyses methods for post-test assessment was a factorial ANCOVA when examining grade point values, and logistic regression when examining retention and graduation/transfer rates (see Table 6).

Table 6

Data Analysis Method Used to Assess Post-test Scores (with Confounding Variables)

Independent Variable	Measurement Scale	Dependent Variable	Measurement Scale	Analysis Method
Engineering TLC program participation (Yes/No)	Nominal (Categorical)	Grade point value (0.0-4.0)	Interval (Continuous)	Factorial ANCOVA
Engineering major (Tech/Eng)	Nominal (Categorical)	Retention (enrolled/not enrolled)	Nominal (Categorical)	Logistic Regression
Age	Interval (Continuous)	Graduation / Transfer (Yes/No)	Nominal (Categorical)	Logistic Regression
High school attended	Nominal (Categorical)			
Gender (Male/Female)	Nominal (Categorical)			
Ethnicity	Nominal (Categorical)			
Full-time / Part-time	Nominal (Categorical)			

Statistical Product and Service Solutions (SPSS) statistical software was used for data analyses of existing student records. The software computes descriptive statistics, bivariate statistics, and prediction for numerical outcomes.

Limitations

Internal Validity

Limitations to internal validity for this study could include instrumentation, statistical regression, and attrition. Instrumentation for this study consists of course exam results. Since the courses were taught and graded by different professors, it is possible that the observed changes could be the result of different professor's standards for rating performance. Statistical regression for this study could pose an internal validity limitation in that students that score extremely high or low could score in a less extreme manner on future tests. That is, students may learn how to take tests, rather than demonstrate improvement in the course content. Attrition for this study could pose an internal validity limitation as members of the two groups drop out of the engineering program (and study) and different rates.

External Validity

The external validity of a research study is the extent to which its results can be generalized to other contexts (Leedy & Ormrod, 2013). A threat to external validity for this study is replication in a different context. Evidence that the study's conclusion has validity and applicability across diverse contexts and situations may be a limitation of the study. While the findings of this study might be applicable to other similar educational institutions, the lack of data from other institutions (other contexts) would not allow verification that the study's findings apply to various contexts.

Other Validity

Since this study does not use random assignment, the two groups may not be similar in every respect prior to the experimental treatment. Therefore, there is no

guarantee that differences between the groups are due entirely to chance. However, the pretest can confirm that the two groups are similar in terms of the dependent variable under investigation.

This study risks experiencing the ceiling effect, which refers to the level at which an independent variable no longer has an effect on a dependent variable. For this study it is possible that the Engineering TLC program (independent variable) may not have an effect on student success and engagement (dependent variables).

CHAPTER 4

FINDINGS

Introduction

This chapter describes the findings for the research questions regarding the effects of implementing an engineering learning community on student success and engagement at a northeastern community college. Results are based on data obtained from a researcher designed survey, student interviews, and existing student records. The findings, both quantitative and qualitative are described according to research question.

Learning Community Activities

A pilot plan entitled "Engineering TLC: Tutors and Learning Communities" was implemented to establish mentoring opportunities, increase course success, increase student retention, increase student engagement and motivation, provide a sense of community, and increase graduation/transfer rates. A summary of activities completed in the engineering learning community is provided in Table 7. The purpose of this study is to investigate whether community college student success and engagement is tied to participation in an engineering learning community.

Table 7
Engineering Learning Community Activities Summary

Weekly Learning Community Meetings (26 total)	
Engineering tutors	
Study groups	
Field Trips (2 total)	
Princeton library construction tour, 4/14/15	
Six Flags Great Adventure, 4/24/15 (roller coaster engineering lecture)	
Conferences (4 total)	
Professional Engineering Society of Mercer County (10/1/14)	
American Society of Highway Engineers (10/15/14)	
Professional Engineering Society of Mercer County (11/5/14)	
Professional Engineering Society of Mercer County (4/14/15)	
Guest Speakers (26 total)	
Working as a team (8/27/14)	Bridge scour countermeasures (12/3/14)
Mentoring, tutoring (9/2/14)	Improving your GPA (1/28/15)
Student engineering chapter (9/10/14)	Professional licensure (2/4/15)
Engineering computations (9/17/14)	Identifying key project issues (2/11/15)
Field trip ideas/work session (9/24/14)	Proposal preparation (2/18/15)
Business cards and networking (10/1/14)	Internships and interviews (2/25/15)
Engineering resumes (10/8/14)	Bridge inspection (3/4/15)
3D printer presentation (10/15/14)	Owning your own business (3/11/15)
Overhead, profit, and engineering fees (10/22/14)	Financial planning (3/25/15)
Project management (10/29/14)	Interview examples and exercise (4/8/15)
Ethics (11/8/14)	Transferring to a university (4/15/15)
How to secure a summer internship (11/12/14)	Preparing plans and specifications (4/22/15)
Work session (11/19/14)	Construction engineering and permits (4/29/15)
Internship opportunity	
Created student resumes	
Distributed student resumes to professional organizations	

Group Demographic Information

This study considered two groups: students who participated in the engineering learning community (treatment group) and students who did not participate in the engineering learning community (control group). Student demographic information was obtained using a researcher designed survey and existing student records.

The first administration of the survey found the control group (*N*=28) was comprised of 11% females, 53% full-time students, and 44% Pell Grant recipients. In

addition 50% of students were white, 7% of students were Asian-Pacific Islander, 18% of students were Hispanic, and 18% of students were African-American (see Table 8). The first administration of the survey found the treatment group (*N*=24) was comprised of 16% females, 58% full-time students, and 21% Pell Grant recipients. In addition 67% of students were white, 8% of students were Asian-Pacific Islander, 8% of students were Hispanic, and 8% of students were African-American. The demographic information for the control and treatment groups was generally aligned. In fact, gender and full-time/part-time data were nearly identical. However, it is noted that the percentage of control group Pell Grant recipients was twice that of the treatment group.

Table 8
Demographic Comparison of Survey 1 Respondents

Demographic Information	Control Group (*N*=28)	Treatment Group (*N*=24)
Female	3 (11%)	4 (16%)
Male	25 (89%)	20 (84%)
Asian	2 (7%)	2 (8%)
African American	5 (18%)	2 (8%)
American Indian	0 (0%)	0 (0%)
Hispanic	5 (18%)	2 (8%)
White	14 (50%)	16 (67%)
Other [a]	2 (7%)	2 (9%)
Full-time student	15 (53%)	14 (58%)
Part-time student	13 (47%)	10 (42%)
Federal Pell Grant recipient	12 (44%)	5 (21%)

[a] Represents groups without significant numbers for comparison.

The second administration of the survey found the control group (*N*=16) was comprised of 6% females, 67% full-time students, and 40% Pell Grant recipients. In addition 44% of students were white, none of the students were Asian-Pacific Islander, 25% of students were Hispanic, and 19% of students were African-American (see Table 9). The second administration of the survey found the treatment group (*N*=23) was

comprised of 9% females, 61% full-time students, and 28% Pell Grant recipients. In addition 61% of students were white, 9% of students were Asian-Pacific Islander, 13% of students were Hispanic, and 13% of students were African-American. The demographic information for the control and treatment groups was generally aligned. In fact, gender and full-time/part-time data were nearly identical. However the percentage of control group Pell Grant recipients was higher than the treatment group.

Table 9
Demographic Comparison of Survey 2 Respondents

Demographic Information	Control Group (*N*=16)	Treatment Group (*N*=23)
Female	1 (6%)	2 (9%)
Male	15 (94%)	21 (91%)
Asian	0 (0%)	2 (9%)
African American	3 (19%)	3 (13%)
American Indian	0 (0%)	0 (0%)
Hispanic	4 (25%)	3 (13%)
White	7 (44%)	14 (61%)
Other [a]	2 (12%)	1 (4%)
Full-time student	10 (67%)	14 (61%)
Part-time student	5 (33%)	9 (39%)
Federal Pell Grant recipient	6 (40%)	6 (28%)

[a] Represents groups without significant numbers for comparison.

The third and final administration of the survey found the control group (*N*=25) was comprised of 4% females, 61% full-time students, and 30% Pell Grant recipients. In addition 40% of students were white, 16% of students were Asian-Pacific Islander, 20% of students were Hispanic, and 16% of students were African-American (see Table 10). The third administration of the survey found the treatment group (*N*=21) was comprised of 10% females, 80% full-time students, and 30% Pell Grant recipients. In addition 68% of students were white, 9% of students were Asian-Pacific Islander, 9% of students were Hispanic, and 9% of students were African-American. The demographic information for

the control and treatment groups aligned closely, and the percentage of control group and treatment group Pell Grant recipients was identical.

Table 10
Demographic Comparison of Survey 3 Respondents

Demographic Information	Control Group (*N*=25)	Treatment Group (*N*=21)
Female	1 (4%)	2 (10%)
Male	24 (96%)	19 (90%)
Asian	4 (16%)	2 (9%)
African American	4 (16%)	2 (9%)
American Indian	0 (0%)	0 (0%)
Hispanic	5 (20%)	2 (9%)
White	10 (40%)	14 (68%)
Other [a]	2 (8%)	1 (5%)
Full-time student	14 (61%)	16 (80%)
Part-time student	9 (39%)	4 (20%)
Federal Pell Grant recipient	7 (30%)	6 (30%)

[a] Represents groups without significant numbers for comparison.

The interviews used selective sampling to allow consideration of gender, ethnicity, and engineering major in the interview results. Seven students in the treatment group were interviewed; while four students in the control group were interviewed. A demographic comparison of interviewed students can be found in Table 11.

Table 11

Demographic Comparison of Interviewed Students

Treatment Group				
Engineering Science	Civil Engineering Technology	Male	Female	Ethnicity
x		x		White
	x	x		Hispanic
x		x		White
x			x	Asian
x		x		White
	x	x		White
x		x		African American

Control Group				
Engineering Science	Civil Engineering Technology	Male	Female	Ethnicity
x		x		African American
	x	x		White
x			x	Asian
x		x		African American

Existing student records were obtained from the community college's office of Institutional Research, Assessment and Planning. The existing database included 93 students; 38 students in the treatment group, and 55 students in the control group (see Table 12). The database was comprised of 8% females, 60% full-time students, 16% Pell Grant recipients, and 68% engineering science majors. In addition, 47% of students were white, 4% of students were Asian-Pacific Islander, 14% of students were Hispanic, and 6% of students were African-American. Thus, the demographic information in the existing database aligned closely with the survey findings.

Table 12
Existing Database Demographics

		N	Percent
Group	Treatment	38	41%
	Control	55	59%
	Total	93	
Major	Engineering Science	63	68%
	Civil Engineering Technology	30	32%
	Total	93	
Gender	Male	86	92%
	Female	7	8%
	Total	93	
Pell Grant Recipient	Yes	15	16%
	No	46	49%
	Missing	32	34%
	Total	93	
Full-time/Part-time	Full-time	56	60%
	Part-time	34	37%
	Missing	3	3%
	Total	93	
Ethnicity	Asian	4	4%
	African American	6	6%
	Hispanic	13	14%
	White	44	47%
	Other	6	6%
	Missing	20	22%
	Total	93	

Group Comparison Prior to Treatment

The research design method used in this study was the nonrandomized control group pretest-posttest design. This design can demonstrate that if the two groups are equivalent with respect to the dependent variable prior to treatment, initial group differences can be eliminated as an explanation for post-treatment differences (Leedy & Ormrod, 2013). The goal, therefore, was to show that the control and treatment groups were equivalent prior to treatment. The initial group comparison considered both the non-cognitive and cognitive domains. The initial survey responses were used to assess the non-cognitive domain, and the composite pre-test scores for pre-calculus, English 1, and Physics 1 were used to assess the cognitive domain.

Non-cognitive domain.

The survey assessed the non-cognitive domain by using Likert response items to examine access to engineering mentors, confidence, access to study groups, engagement and motivation, and student relationships (see Figure 6). Survey results for access to engineering mentors found 72% of the control group were satisfied, and 3% were not satisfied. The treatment group survey found 71% were satisfied, and 13% were not satisfied. A non-parametric Mann-Whitney test was performed to determine if the differences were significant. The control group access to engineering mentors ($Mdn = 4$) did not differ significantly from the treatment group ($Mdn = 4$), $U = 340.00$, $z = -.15$, $p = .88$, $r = -.02$ (see Table 13). This represents a small effect size.

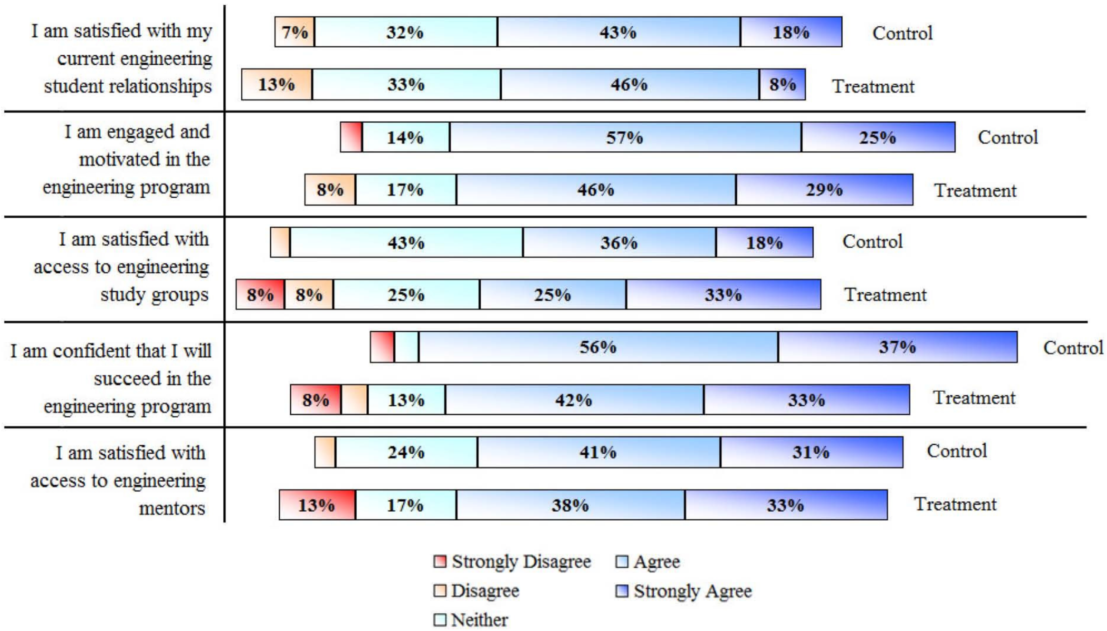

Figure 6. Diverging stacked bar chart: Survey 1 responses

Table 13

Fall Survey Response Statistics

	Group	*N*	Median	Mode	*U*	*z*	Sig.	*r*
Question 1	Control	29	4	4	340.00	-.15	.880	-.02
Access to mentors	Treatment	24	4	4				
	Total	53						
Question 2	Control	27	4	4	277.50	-.96	.338	-.13
Confidence	Treatment	24	4	4				
	Total	51						
Question 3	Control	28	4	3	317.00	-.36	.715	-.05
Access to study groups	Treatment	24	4	5				
	Total	52						
Question 4	Control	28	4	4	328.50	-.15	.880	-.02
Motivation	Treatment	24	4	4				
	Total	52						
Question 5	Control	28	4	4	293.00	-.84	.399	-.12
Student relationships	Treatment	24	4	4				
	Total	52						

Survey results for confidence found 93% of the control group were confident, and 3% were not confident. The treatment group survey found 75% were confident, and 13% were not confident. While the control group reported a higher confidence level than the treatment group, the control group confidence (*Mdn* = 4) did not differ significantly from the treatment group (*Mdn* = 4), $U = 277.50$, $z = -.96$, $p = .34$, $r = -.13$. This represents a small effect size.

Survey results for access to engineering study groups found 54% of the control group were satisfied, and 3% were not satisfied. The treatment group survey found 58% were satisfied, and 17% were not satisfied. The control group access to study groups (*Mdn* = 4) did not differ significantly from the treatment group (*Mdn* = 4), $U = 317.00$, $z = -.36$, $p = .71$, $r = -.05$. This represents a small effect size.

Survey results for engagement and motivation found 82% of the control group were satisfied, and 3% were not satisfied. The treatment group survey found 75% were satisfied, and 8% were not satisfied. The control group engagement and motivation (*Mdn* = 4) did not differ significantly from the treatment group (*Mdn* = 4), $U = 328.50$, $z = -.15$, $p = .88$, $r = -.02$. This represents a small effect size.

Lastly, survey results for student relationships found 61% of the control group were satisfied, and 7% were not satisfied. The treatment group survey found 54% were satisfied, and 13% were not satisfied. The control group student relationships (*Mdn* = 4) did not differ significantly from the treatment group (*Mdn* = 4), $U = 293.00$, $z = -.84$, $p = .40$, $r = -.12$. This represents a small effect size. Thus, the control and treatment groups were equivalent prior to treatment considering the non-cognitive domain indicators.

Cognitive domain.

The composite pre-test scores considered the cognitive domain by examining grade point values for pre-calculus, English 1, and Physics 1. An independent *t*-test was used to examine grade point values for each of the three pre-test courses. The assumptions of the independent *t*-test are: scores are independent, data are measured at least at the interval level, variances in the populations are roughly equal (homogeneity of variance), and the sampling distribution is normally distributed (Field, 2009).

The course grade point scores are independent, and the data are measured at the interval level, thus the first two assumptions were met. Levene's test was used to examine the homogeneity of variance for each pre-test course. Levene's test indicated equal variances for pre-calculus, $F(1, 76) = .33$, $p = .57$, English 1, $F(1, 77) = .78$, $p = .38$, and Physics 1, $F(1, 56) = .00$, $p = .96$. Thus, the third assumption was met.

The data were investigated for potential outliers. The dependent variables (pre-test scores) were first converted to z-scores. A z-score is a number that results from the transformation of a raw score into units of standard deviation (Sprintall, 2012). A z-score greater than 3.29 constitutes an outlier (Field, 2009). Therefore, the absolute value of any z-score found to exceed 3.29 was considered to be an outlier. The analysis revealed no outliers for any of the dependent variables. The dependent variables were tested for normality by examining skewness and kurtosis. Each of the dependent variables were found to be non-normal. Data transformations were employed to attempt to achieve normality, however, resulting distributions continued to be non-normal, which violated the assumption for an independent *t*-test. However, it has often been reported that violation of the normality assumption is of little concern (Glass, Peckham, & Sanders,

1972). Rider (1929) and Pearson (1929, 1931) found little effect of non-normality on the two-tailed *t*-test. Cochran (1947) indicated that the consensus of studies was that no serious errors were introduced by non-normality in the significance levels of the two-tailed *t*-test. This view is consistent with more recent literature that reports the normality assumption to be of little concern (Boneau, 1960; Havlicek & Peterson, 1974; Lix, Keselman, & Keselman, 1996; Zimmerman, 1987). Thus, the independent *t*-test analyses were performed with the non-normal distributions of the dependent variables.

Pre-calculus grade point values for the treatment group ($M = 3.08$, $SE = .13$) did not differ significantly from the control group ($M = 3.01$, $SE = .15$), $t(76) = .36$, $p = .72$, $r = .04$ (see Table 14). This represents a small effect size. English 1 grade point values for the treatment group ($M = 3.20$, $SE = .12$) did not differ significantly from the control group ($M = 2.93$, $SE = .09$), $t(77) = 1.83$, $p = .07$, $r = .20$. This represents a small to medium effect size. Physics 1 grade point values for the treatment group ($M = 3.10$, $SE = .14$) did not differ significantly from the control group ($M = 3.22$, $SE = .15$), $t(56) = -.59$, $p = .56$, $r = .08$. This represents a small effect size. Hence, the control and treatment groups were equivalent prior to treatment considering the cognitive domain indicators.

Table 14
Pre-test Grade Point Statistics

Course	Group	*N*	*M*	*SE*	*t*	*df*	Sig.	*r*
English 1	Treatment	36	3.20	.12	1.83	77	.071	.20
	Control	43	2.93	.09				
	Total	79						
Pre-Calculus	Treatment	37	3.08	.13	.36	76	.722	.04
	Control	41	3.01	.15				
	Total	78						
Physics 1	Treatment	32	3.10	.14	-.59	56	.559	.08
	Control	26	3.22	.15				
	Total	58						

Note: Non-parametric Mann-Whitney tests were also performed and confirmed the pre-test grades were not significant.

In sum, a comparison of the control and treatment groups prior to participation in the engineering learning community showed that the two groups were equivalent with respect to the dependent variables, considering both cognitive and non-cognitive domain indicators. Thus, initial group differences can be eliminated as an explanation for post-treatment differences.

Research Question 1: What is the relationship between course success and participation in the Engineering TLC program?

The post-test scores examined grade point values for statics, mechanics of materials, and Physics 2. An independent *t*-test was used to examine grade point values for each of the three post-test courses. The assumptions of the independent *t*-test are: scores are independent, data are measured at least at the interval level, variances in the populations are roughly equal (homogeneity of variance), and the sampling distribution is normally distributed (Field, 2009).

The course grade point scores are independent, and the data are measured at the

interval level, thus the first two assumptions were met. Levene's test was used to examine the homogeneity of variance for each post-test course. Levene's test indicated unequal variances for statics ($F(1, 58) = 13.89$, $p = .00$), and mechanics of materials ($F(1, 35) = 5.55$, $p = .02$). Levene's test indicated equal variances for Physics 2 ($F(1, 39) = 2.74$, $p = .11$). Thus, the third assumption was violated for statics and mechanics of materials. However, it has been reported that the *t*-test is robust to this assumption as long as group sizes are equal (Glass, 1966). Equal group sizes may be defined by the ratio of the largest to smallest group being less than 1.5 (O'Neill & Mathews, 2002; Statistic Solutions, 2013). For this study, there were 55 students in the control group and 38 students in the treatment group. Thus, the ratio of largest to smallest group is 1.45, allowing the group size to be considered equal. Hence, the independent *t*-test analyses can be performed without homogeneity of variances.

The data was investigated for potential outliers. The dependent variables (post-test scores) were first converted to z-scores. A z-score greater than 3.29 constitutes an outlier (Field, 2009). Therefore, the absolute value of any z-score found to exceed 3.29 was considered to be an outlier. The analysis revealed no outliers for any of the dependent variables. The dependent variables were tested for normality by examining skewness and kurtosis. Each of the dependent variables were found to be non-normal. Data transformations were employed to attempt to achieve normality, however, resulting distributions continued to be non-normal, which violated the assumption for an independent *t*-test. However, as discussed for the pre-tests, it has often been reported that violation of the normality assumption is of little concern (Glass, Peckham, & Sanders, 1972). No serious errors are introduced by non-normality in the significance levels of the

two-tailed *t*-test (Boneau, 1960; Cochran, 1947; Havlicek & Peterson, 1974; Lix, Keselman, & Keselman, 1996; Pearson, 1929, 1931; Rider,1929; Zimmerman, 1987). Thus, the independent *t*-test analyses were performed with the non-normal distributions of the dependent variables.

Statics grade point values for the treatment group (M = 3.65, SE = .09) did not differ significantly from the control group (M = 3.33, SE = .16), $t(58) = 1.82$, $p = .07$, $r = .23$ (see Table 15). This represents a small to medium effect size. In addition, Physics 2 grade point values for the treatment group (M = 3.22, SE = .18) did not differ significantly from the control group (M = 3.41, SE = .18), $t(39) = -.73$, $p = .47$, $r = .12$. This represents a small effect size. Thus, students that participated in the learning community did not experience statistically significant differences in statics or Physics 2 post-test results.

Table 15
Post-test Grade Point Statistics

Course	Group	*N*	*M*	*SE*	*t*	*df*	Sig.	*r*
Statics	Treatment	34	3.65	.09	1.82	58	.074	.23
	Control	26	3.33	.16				
	Total	60						
Mechanics of Materials	Treatment	20	3.71	.12	2.18	35	.036*	.35
	Control	17	3.19	.22				
	Total	37						
Physics 2	Treatment	25	3.22	.18	-.73	39	.470	.12
	Control	16	3.41	.18				
	Total	41						

* $p \leq .05$
Note: Non-parametric Mann-Whitney tests were also performed and confirmed the post-test significance.

Mechanics of materials grade point values for the treatment group (M = 3.71,

SE = .12) did differ significantly from the control group (*M* = 3.19, *SE* = .22), $t(35) = 2.18$, $p = .04$, $r = .35$. This represents a medium effect size. Hence, students that participated in the learning community did experience a statistically significant improvement in mechanics of materials post-test results.

The relationship between course success and participation in the Engineering TLC program is generally positive. Students that participated in the Engineering TLC program experienced a significant improvement in grade point value for one of the three post-test courses studied.

Research Question 1a: What is the relationship between course success and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

The post-test scores examined grade point values for statics, mechanics of materials, and Physics 2. An analysis of variance (ANOVA) was used to examine grade point values for each of the three post-test courses. Prior to performing an ANOVA, the following assumptions must be satisfied: the dependent variable must be measured at the interval or ratio level, the independent variable must consist of two or more categorical independent groups, there must be independence of observations, there should be no significant outliers, the dependent variable should be approximately normal for each category of the independent variable, and there must be homogeneity of variances (Laerd, 2013).

For this analysis, the dependent variables were measured at the interval level, and the independent variable consisted of two categorical independent groups, thus the first two assumptions were met. There were independence of observations, as the post-test

scores were observed and recorded independently, thus the third assumption was met. The data was investigated for potential outliers. The analysis revealed no outliers for any of the dependent variables, thus the fourth assumption was met.

The dependent variables were tested for normality by examining skewness and kurtosis. Each of the dependent variables were found to be non-normal. Data transformations were employed to attempt to achieve normality, however, resulting distributions continued to be non-normal, which violated the assumption for an ANOVA. However, much of the research on violations of the normality assumption has been consistent in noting the relative insensitivity of ANOVA to departures from normality (Lix, Keselman & Keselman, 1996). For example, Cochran (1947) observed that non-normality appeared to have little effect on Type I error performance, a point echoed by Wilcox (1995). Glass, Peckham and Sanders (1972) concurred with these observations and concluded that skewed populations had little effect on the level of significance. Field (2009) summarized by stating that when group sizes are equal, ANOVA is quite robust to violations of normality. Equal group sizes may be defined by the ratio of the largest to smallest group being less than 1.5 (O'Neill & Mathews, 2002; Statistic Solutions, 2013). For this study, there were 55 students in the control group and 38 students in the treatment group. Thus, the ratio of largest to smallest group is 1.45, allowing the group size to be considered equal. Thus an ANOVA could be performed with the non-normal distributions of the dependent variables.

Levene's test was used to examine the homogeneity of variance for each post-test course. Levene's test indicated unequal variances for statics ($F(1, 58) = 13.89$, $p = .00$), and mechanics of materials ($F(1, 35) = 5.55$, $p = .02$). Levene's test indicated equal

variances for Physics 2 ($F(1, 39) = 2.74$, $p = .11$). Thus, the homogeneity of variance assumption was violated for statics and mechanics of materials. However, it has been reported that ANOVA is robust to this assumption as long as group sizes are equal (Glass, 1966). Since this study's group size can be considered equal, the ANOVA could be performed without homogeneity of variances.

There was no significant effect of participation in the Engineering TLC program on statics grade point values, $F(1,58) = 3.30$, $p = .07$, $\eta_p^2 = .054$ (see Table 16). However, there was a significant effect of participation in the Engineering TLC program on mechanics of materials grade point values, $F(1,35) = 4.77$, $p = .04$, $\eta_p^2 = .120$ (see Table 17). Lastly, there was no significant effect of participation in the Engineering TLC program on Physics 2 grade point values, $F(1,39) = .53$, $p = .47$, $\eta_p^2 = .013$ (see Table 18). The effect size for each condition was small. These results are consistent with the results from the *t*-tests used to assess the first research question.

Table 16
Post-test Grade Point Statistics for Statics

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1.46[a]	1	1.46	3.30	.074	.054
Intercept	718.76	1	718.76	1619.35	.000	.965
Group	1.46	1	1.46	3.30	.074	.054
Error	25.74	58	.444			
Total	767.82	60				
Corrected Total	27.21	59				

a. R Squared = .054 (Adjusted R Squared = .038)

Table 17
Post-test Grade Point Statistics for Mechanics of Materials

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	2.50[a]	1	2.50	4.77	.036	.120
Intercept	437.27	1	437.27	833.78	.000	.960
Group	2.50	1	2.50	4.77	.036*	.120
Error	18.36	35	.524			
Total	466.44	37				
Corrected Total	20.86	36				

a. R Squared = .120 (Adjusted R Squared = .095)
* $p \leq .05$

Table 18
Post-test Grade Point Statistics for Physics 2

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	.38[a]	1	.38	.53	.47	.013
Intercept	428.65	1	428.65	605.65	.000	.939
Group	.38	1	.38	.53	.47	.013
Error	27.61	39	.71			
Total	472.50	41				
Corrected Total	27.99	40				

a. R Squared = .13 (Adjusted R Squared = .012)

To consider covariates in the research question, an analysis of covariance (ANCOVA) was required. ANCOVA has two additional assumptions beyond the assumptions for an ANOVA: independence of the covariate and treatment effect, and homogeneity of regression slopes (Field, 2009).

To test the independence of the covariates and the treatment effects, an ANOVA was performed with each covariate as the outcome variable (see Table 19). The goal was to verify that the covariates were roughly equal across levels of the independent variables (Field, 2009). The results of the analyses show 33 of the 36 values were insignificant,

meaning there was independence of the covariates and the treatment effects. Thus, the covariates were roughly equal across levels of the independent variables, and this assumption was satisfied.

Table 19

Independence of the Independent Variables and the Covariates

Covariate	Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.
Major	Gender	.11	1	.11	.62	.436
	Age	.33	1	.33	1.85	.180
	Pell Grant	.20	1	.20	1.15	.288
	Full-time/Part-time	2.37	1	2.37	13.30	.001*
	Ethnicity	.03	1	.03	.18	.672
	Group	.05	1	.05	.29	.590
	Error	9.28	52	.18		
Gender	Age	.01	1	.01	.15	.70
	Pell Grant	.05	1	.05	1.08	.30
	Full-time/Part-time	.13	1	.13	2.69	.11
	Ethnicity	.14	1	.14	2.89	.09
	Major	.03	1	.03	.62	.44
	Group	.00	1	.00	.00	.95
	Error	2.54	52	.05		
Age	Pell Grant	38.61	1	38.61	1.03	.315
	Full-time/Part-time	202.86	1	202.86	5.42	.024*
	Ethnicity	18.74	1	18.74	.50	.482
	Major	69.18	1	69.18	1.85	.180
	Gender	5.72	1	5.72	.15	.698
	Group	9.38	1	9.38	.25	.619
	Error	1946.69	52	37.44		
Pell Grant	Full-time/Part-time	.04	1	.04	.23	.634
	Ethnicity	.24	1	.24	1.28	.263
	Major	.22	1	.22	1.15	.288
	Gender	.20	1	.20	1.08	.304
	Age	.20	1	.20	1.03	.315
	Group	.33	1	.33	1.71	.197
	Error	9.89	52	.19		
Full-time/Part-time	Ethnicity	.10	1	.10	.65	.425
	Major	2.02	1	2.02	13.30	.001*
	Gender	.41	1	.41	2.69	.107
	Age	.82	1	.82	5.42	.024*
	Pell Grant	.03	1	.03	.23	.634
	Group	.00	1	.00	.00	.942
	Error	7.90	52	.15		
Ethnicity	Major	.33	1	.33	.18	.672
	Gender	5.20	1	5.2	2.89	.095
	Age	.90	1	.90	.50	.482
	Pell Grant	2.30	1	2.3	1.28	.263
	Full-time/Part-time	1.16	1	1.16	65	.425
	Group	.25	1	.25	.14	.710
	Error	93.61	52	1.80		

* $p \leq .05$

The homogeneity of regression slopes was checked to determine if the relationship between the dependent variables and the covariates were the same in each group (Field, 2009). To test this assumption, an ANCOVA was performed by including the interaction between covariates and the independent variable.

When the homogeneity of regression slopes were checked with statics as the dependent variable, 20 of the 21 interactions were not significant (see Table 20). When the homogeneity of regression slopes were checked with mechanics of materials as the dependent variable, all of the interactions were not significant (see Table 21). Finally, when the homogeneity of regression slopes were checked with Physics 2 as the dependent variable, all of the interactions were not significant (see Table 22). Thus, the homogeneity of regression slopes assumption was satisfied.

Table 20

Homogeneity of Regression Slopes with Statics as a Dependent Variable

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.
Age * Ethnicity	.41	1	.41	1.61	.216
Age * Full-time/Part-time	.32	1	.32	1.22	.279
Gender * Age	.00	0	-	-	-
Group * Age	.31	1	.31	1.18	.287
Major * Age	.10	1	.10	.38	.543
Age * Pell Grant	.32	1	.32	1.24	.275
Full-time/Part-time * Ethnicity	.05	1	.05	.20	.662
Gender * Ethnicity	.00	0	-	-	-
Group * Ethnicity	.01	1	.01	.05	.831
Major * Ethnicity	.08	1	.08	.29	.593
Pell Grant * Ethnicity	.06	1	.06	.21	.647
Gender * Full-time/Part-time	.00	0	-	-	-
Group * Full-time/Part-time	.01	1	.01	.03	.855
Major * Full-time/Part-time	.01	1	.01	.04	.848
Pell Grant * Full-time/Part-time	.05	1	.05	.20	.661
Group * Gender	.00	0	-	-	-
Major * Gender	.00	0	-	-	-
Gender * Pell Grant	.00	0	-	-	-
Group * Major	.28	1	.28	1.08	.307
Group * Pell Grant	1.57	1	1.57	6.07	.021*
Major * Pell Grant	.01	1	.01	.042	.839
Error	6.73	26	.26		

* $p \leq .05$

Table 21

Homogeneity of Regression Slopes with Mechanics of Materials as a Dependent Variable

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.
Age * Ethnicity	.32	1	.32	.79	.398
Age * Full-time/Part-time	.57	1	.57	1.39	.269
Gender * Age	.00	0	-	-	-
Group * Age	.04	1	.04	.09	.765
Major * Age	.68	1	.68	1.65	.231
Age * Pell Grant	.31	1	.31	.76	.406
Full-time/Part-time * Ethnicity	.13	1	.13	.33	.581
Gender * Ethnicity	.00	0	-	-	-
Group * Ethnicity	.69	1	.69	1.66	.229
Major * Ethnicity	.77	1	.77	1.86	.206
Pell Grant * Ethnicity	.09	1	.09	.21	.657
Gender * Full-time/Part-time	.00	0	-	-	-
Group * Full-time/Part-time	.01	1	.01	.04	.852
Major * Full-time/Part-time	.47	1	.47	1.14	.313
Pell Grant * Full-time/Part-time	.01	1	.01	.01	.911
Group * Gender	.00	0	-	-	-
Major * Gender	.00	0	-	-	-
Gender * Pell Grant	.00	0	-	-	-
Group * Major	1.00	1	1	2.44	.153
Group * Pell Grant	.16	1	.16	.39	.546
Major * Pell Grant	.37	1	.37	.41	.368
Error	3.71	9	.41		

Table 22

Homogeneity of Regression Slopes with Physics 2 as a Dependent Variable

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.
Age * Ethnicity	2.99	1	2.99	4.66	.056
Age * Full-time/Part-time	.18	1	.18	.28	.607
Gender * Age	.00	0	-	-	-
Group * Age	.22	1	.22	.34	.571
Major * Age	.01	1	.01	.00	.955
Age * Pell Grant	0.88	1	0.88	1.37	.269
Full-time/Part-time * Ethnicity	.02	1	.02	.03	.863
Gender * Ethnicity	.00	0	-	-	-
Group * Ethnicity	.01	1	.01	.01	.906
Major * Ethnicity	.06	1	.06	.09	.773
Pell Grant * Ethnicity	.54	1	.54	.84	.382
Gender * Full-time/Part-time	.00	0	-	-	-
Group * Full-time/Part-time	1.23	1	1.23	1.91	.197
Major * Full-time/Part-time	.08	1	.08	.13	.728
Pell Grant * Full-time/Part-time	.90	1	.90	1.41	.263
Group * Gender	.00	0	-	-	-
Major * Gender	.00	0	-	-	-
Gender * Pell Grant	.00	0	-	-	-
Group * Major	.42	1	.42	.66	.437
Group * Pell Grant	.63	1	.63	.99	.344
Major * Pell Grant	.10	1	.10	.15	.703
Error	6.40	9	.64		

Statics grade point values were not significantly related to participation in the Engineering TLC program when considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status as covariates, $F(1,41) = 2.22$, $p = .14$, $\eta_p^2 = .051$. The effect size was found to be small. In fact, statics grade point values were not significantly related to any of the covariates (see Table 23).

Table 23

Post-test Grade Point Statistics for Statics (with Confounding Variables)

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	4.85[a]	7	.69	1.64	.151	.219
Intercept	3.56	1	3.56	8.45	.006	.171
Major	1.28	1	1.28	3.05	.088	.069
Gender	.97	1	.97	2.30	.137	.053
Age	.68	1	.68	1.60	.213	.038
Pell Grant	1.33	1	1.33	3.15	.083	.071
Full-time/Part-time	.50	1	.50	1.17	.285	.028
Ethnicity	.71	1	.71	1.68	.202	.039
Group	.94	1	.94	2.22	.143	.051
Error	17.30	41	.422			
Total	630.12	49				
Corrected Total	22.14	48				

a. R Squared = .219 (Adjusted R Squared = .085)

Mechanics of materials grade point values were not significantly related to participation in the Engineering TLC program when considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status as covariates, $F(1,41) = 2.95$, $p = .10$, $\eta_p^2 = .109$. The effect size was found to be small. The only covariate that was significantly related to Physics 2 grade point values was age $F(1,41) = 5.35$, $p = .03$, $\eta_p^2 = .182$ (see Table 24). However, the effect size was small to medium.

Table 24

Post-test Grade Point Statistics for Mechanics of Materials (with Confounding Variables)

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6.08[a]	7	.87	1.74	.146	.337
Intercept	5.43	1	5.43	10.90	.003	.312
Major	.54	1	.54	1.08	.309	.043
Gender	.68	1	.68	1.37	.253	.054
Age	2.66	1	2.66	5.35	.030*	.182
Pell Grant	1.14	1	1.14	2.30	.143	.087
Full-time/Part-time	.67	1	.67	1.35	.257	.053
Ethnicity	.07	1	.07	.13	.719	.006
Group	1.47	1	1.47	2.95	.099	.109
Error	11.96	41	.50			
Total	419.19	49				
Corrected Total	18.04	48				

a. R Squared = .337 (Adjusted R Squared = .144)

* $p \leq .05$

Physics 2 grade point values were not significantly related to participation in the Engineering TLC program when considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status as covariates, $F(1,25) = .42$, $p = .52$, $\eta_p^2 = .016$. The effect size was found to be small. In fact, Physics 2 grade point values were not significantly related to any of the covariates (see Table 25).

Table 25

Post-test Grade Point Statistics for Physics 2 (with Confounding Variables)

Source	Type III Sum of Squares	*df*	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	6.27[a]	7	.90	1.39	.251	.281
Intercept	1.09	1	1.09	1.69	.205	.063
Major	.18	1	.18	.28	.599	.011
Gender	.57	1	.57	.90	.353	.035
Age	1.74	1	1.74	2.71	.112	.098
Pell Grant	1.01	1	1.01	1.57	.222	.059
Full-time/Part-time	2.54	1	2.54	3.96	.058	.137
Ethnicity	.63	1	.63	.99	.330	.038
Group	.27	1	.27	.42	.523	.016
Error	16.06	25	.64			
Total	385.67	33				
Corrected Total	22.33	32				

a. R Squared = .281 (Adjusted R Squared = .079)

The analyses revealed no significant relationship between course success and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status as confounding variables.

Research Question 2: What is the relationship between fall-to-spring retention and participation in the Engineering TLC program?

The relationship between fall-to-spring retention and participation in the Engineering TLC program was examined using both a chi-square test and logistic regression.

Chi-square test.

The chi-square test assumes that expected frequencies are greater than 5 (Field, 2009). This assumption was by checked by generating a group-retention crosstabulation, and examining the 'expected count' values (see Table 26). All expected frequencies were

greater than 5, thus, the assumption of the chi-square test was satisfied.

Table 26

Group-Retention Crosstabulation

			Retention		
			No	Yes	Total
Group	Control	Count	12	43	55
		Expected Count	8.3	46.7	55
		% within Group	21.8%	78.2%	100.0%
		% within Retention	85.7%	54.4%	59.1%
		% of Total	12.9%	46.2%	59.1%
		Std. Residual	1.3	-.5	
	Treatment	Count	2	36	38
		Expected Count	5.7	32.3	38
		% within Group	5.3%	94.7%	100.0%
		% within Retention	14.3%	45.6%	40.9%
		% of Total	2.2%	38.7%	40.9%
		Std. Residual	-1.6	.7	
Total		Count	14	79	93
		Expected Count	14.0	79.0	93
		% within Group	15.1%	84.9%	100.0%
		% within Retention	100.0%	100.0%	100.0%
		% of Total	15.1%	84.9%	100.0%

There was a significant association between participation in the Engineering TLC program and fall-to-spring retention, $\chi^2(1) = 4.82$, $p = .03$ (see Table 27). This indicates that, based on the odds ratio, the odds of retention were 5.02 times higher for students that participated in the Engineering TLC program.

Table 27
Retention Statistics

	Value	*df*	Sig.	Odds Ratio
Pearson Chi-Square	4.817[a]	1	.028*	5.02
Likelihood Ratio	5.421	1	.020*	
N of Valid Cases	93			

a. No cells have expected count less than 5. The minimum expected count is 5.72.
* $p \leq .05$

Logistic regression.

Logistic regression yielded a significant association between participation in the Engineering TLC program and fall-to-spring retention, $\chi^2(1) = 4.11$, $p = .04$ (see Table 28). This again indicates that, based on the odds ratio, the odds of retention were 5.02 times higher for students that participated in the Engineering TLC program.

Table 28
Logistic Regression Results for Retention

Measure	*B (SE)*	Wald χ^2	Sig.	Odds Ratio**	95% Confidence Interval Lower	95% Confidence Interval Upper
Group (Control/Treatment)	1.61 (.80)	4.11	.043*	5.02	1.05	23.93

**Increase in the odds of occurrence with one unit change in the independent variable.
* $p \leq .05$

Thus, there was a significant relationship between fall-to-spring retention and participation in the Engineering TLC program. Students that participated in the Engineering TLC program were much more likely to re-enroll in spring classes.

Research Question 2a: What is the relationship between fall-to-spring retention and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

Logistic regression was used to investigate the relationship between fall-to-spring retention and participation in the Engineering TLC program considering several covariates. The covariates were engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status.

Logistic regression yielded no significant association between participation in the Engineering TLC program and fall-to-spring retention, $\chi^2(1) = .00$, $p = .99$ (see Table 29). Students that participated in the Engineering TLC program were just as likely to re-enroll in spring classes as students in the control group. In fact, none of the confounding variables yielded a significant association with fall-to-spring retention.

Table 29
Logistic Regression Results for Retention (with Confounding Variables)

Measure	*B (SE)*	Wald χ^2	Sig.	Odds Ratio**	95% Confidence Interval Lower	Upper
Group (Control/Treatment)	-.018 (2.14)	.00	.993	.982	.02	64.83
Major	-31.79 (6842.09)	.00	.996	.000	.00	-
Gender	18.21 (5151.61)	.00	.997	***	.00	-
Age	.09 (.17)	.27	.601	1.090	.79	1.51
Pell Grant Recipient	.661 (2.11)	.10	.754	1.937	.03	121.78
Full-time/Part-time	-17.80 (4743.96)	.00	.997	.000	.00	-
Ethnicity	.64 (.60)	1.10	.294	1.888	.58	6.19

**Increase in the odds of occurrence with one unit change in the independent variable.
***Greater than 10000

Research Question 3: What is the relationship between graduation/transfer rates and participation in the Engineering TLC program?

The relationship between graduation/transfer rates and participation in the Engineering TLC program was examined using both a chi-square test and logistic regression.

Chi-square test.

The chi-square test assumes that expected frequencies are greater than 5 (Field, 2009). This assumption was by checked by generating a group-graduation crosstabulation, and examining the 'expected count' values (see Table 30). All expected frequencies were greater than 5, thus, the assumption of the chi-square test was satisfied.

Table 30
Group-Graduation/Transfer Crosstabulation

			Graduation/Transfer		
			No	Yes	Total
Group	Control	Count	35	20	55
		Expected Count	26.6	28.4	55
		% within Group	63.6%	36.4%	100.0%
		% within Graduation/Transfer	77.8%	41.7%	59.1%
		% of Total	37.6%	21.5%	59.1%
		Std. Residual	1.6	-1.6	
	Treatment	Count	10	28	38
		Expected Count	18.4	19.6	38
		% within Group	26.3%	73.7%	100.0%
		% within Graduation/Transfer	22.2%	58.3%	40.9%
		% of Total	10.8%	30.1%	40.9%
		Std. Residual	-2.0	1.9	
Total		Count	45	48	93
		Expected Count	45.0	48.0	93
		% within Group	48.4%	51.6%	100.0%
		% within Graduation/Transfer	100.0%	100.0%	100.0%
		% of Total	48.4%	51.6%	100.0%

There was a significant association between participation in the Engineering TLC program and graduation/transfer, $\chi^2(1) = 12.53$, $p = .00$ (see Table 31). This indicates that, based on the odds ratio, the odds of graduating or transferring were 4.9 times higher for students that participated in the Engineering TLC program.

Table 31
Graduation/Transfer Statistics

	Value	*df*	Sig.	Odds Ratio
Pearson Chi-Square	12.533[a]	1	.000*	4.90
Likelihood Ratio	12.924	1	.000*	
N of Valid Cases	93			

a. No cells have expected count less than 5. The minimum expected count is 18.39.
* $p \leq .05$

Logistic regression.

Logistic regression yielded a significant association between participation in the Engineering TLC program and graduation/transfer, $\chi^2(1) = 11.79$, $p = .00$ (see Table 32). This again indicates that, based on the odds ratio, the odds of graduating or transferring were 4.9 times higher for students that participated in the Engineering TLC program.

Table 32
Logistic Regression Results for Graduation/Transfer

		Wald			95% Confidence Interval	
Measure	*B (SE)*	χ^2	Sig.	Odds Ratio**	Lower	Upper
Group (Control/Treatment)	1.59 (.46)	11.79	.001*	4.9	1.98	12.14

**Increase in the odds of occurrence with one unit change in the independent variable.
* $p \leq .05$

Thus, there was a significant relationship between participation in the Engineering TLC program and graduation/transfer. Students that participated in the Engineering TLC

program were much more likely to graduate or transfer.

Research Question 3a: What is the relationship between graduation/transfer rates and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

Logistic regression was used to investigate the relationship between graduation/transfer and participation in the Engineering TLC program considering several covariates. The covariates were engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status. Logistic regression yielded no significant association between participation in the Engineering TLC program and graduation/transfer, $\chi^2(1) = 3.63$, $p = .06$ (see Table 33).

Table 33

Logistic Regression Results for Graduation/Transfer (with Confounding Variables)

Measure	*B (SE)*	Wald χ^2	Sig.	Odds Ratio**	95% Confidence Interval Lower	95% Confidence Interval Upper
Group (Control/Treatment)	1.29 (.68)	3.63	.057	3.65	.96	13.8
Major	-.80 (.76)	1.09	.297	.450	.10	2.02
Gender	1.49 (1.50)	.98	.323	4.427	.23	84.58
Age	.164 (.08)	4.09	.043*	1.178	1.00	1.38
Pell Grant Recipient	-1.49 (.81)	3.34	.067	.226	.05	1.13
Full-time/Part-time	.20 (.81)	.05	.817	1.206	.25	5.90
Ethnicity	-4.20 (2.55)	.17	.681	1.101	.69	1.74

**Increase in the odds of occurrence with one unit change in the independent variable.

* $p \leq .05$

Research Question 4: How effective is the Engineering TLC program in providing mentoring opportunities?

The effectiveness of the Engineering TLC program to provide mentoring opportunities was assessed using survey data and interviews. Survey data were used to compare changes in student responses after exposure in the Engineering TLC program. The interviews were used to investigate student experiences in the Engineering TLC program.

Survey results.

Survey data were used to examine changes in student responses after one and two semesters in the Engineering TLC program. Initial survey results for access to engineering mentors found 71% of the treatment group were satisfied, and 13% were not satisfied. A second administration of the survey (after one semester in the Engineering TLC program) found 96% were satisfied, and 0% were not satisfied (see Figure 7). A non-parametric Mann-Whitney test was performed to determine if the differences were significant. The initial group responses ($Mdn = 4$) did differ significantly from the second administration of the survey ($Mdn = 5$), $U = 183.50$, $z = -2.13$, $p = .03$, $r = -.31$ (see Table 34). This represents a medium effect size.

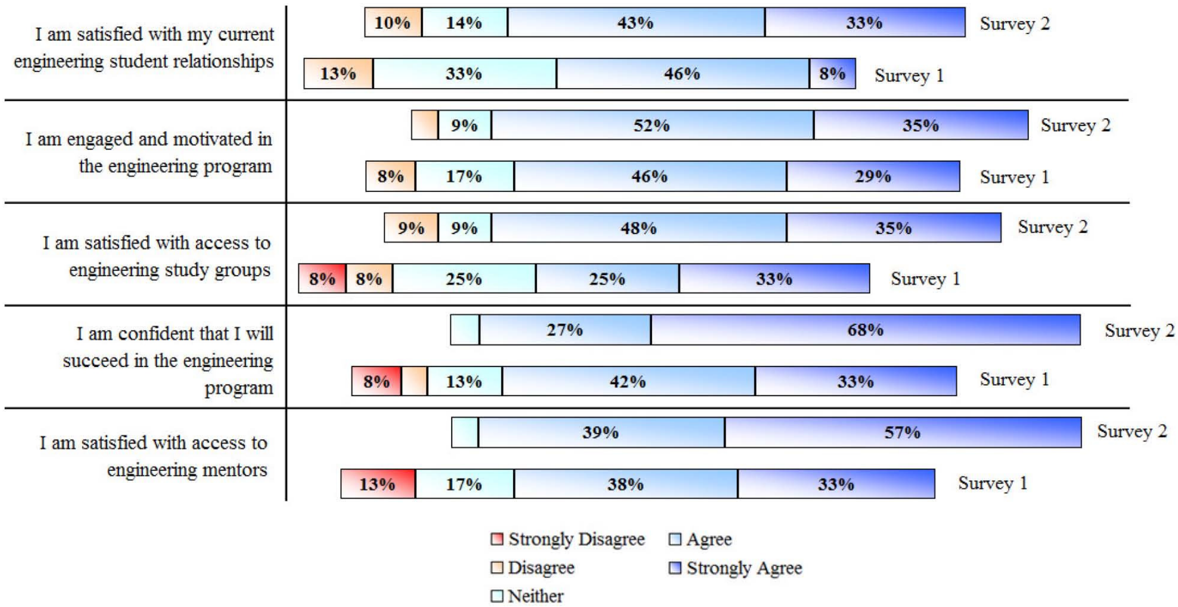

Figure 7. Diverging stacked bar chart: Treatment group responses for Survey 1 and Survey 2

Table 34

Treatment Group Response Statistics, Survey 1 to Survey 2

	Survey	*N*	Median	Mode	*U*	*z*	Sig.	*r*
Question 1	Survey 1	24	4	4	183.50	-2.13	.033*	-.31
Access to mentors	Survey 2	23	5	5				
	Total	47						
Question 2	Survey 1	24	4	4	157.50	-2.57	.010*	-.38
Confidence	Survey 2	22	5	5				
	Total	46						
Question 3	Survey 1	24	4	5	229.00	-1.05	.294	-.15
Access to study groups	Survey 2	23	4	4				
	Total	47						
Question 4	Survey 1	24	4	4	241.00	-.81	.419	-.12
Motivation	Survey 2	23	4	4				
	Total	47						
Question 5	Survey 1	24	4	4	170.50	-1.97	.049*	-.29
Student relationships	Survey 2	21	4	4				
	Total	45						

* $p \leq .05$

The third administration of the survey (after two semester in the Engineering TLC program) found 95% of students were satisfied, and 5% were not satisfied (see Figure 8). A non-parametric Mann-Whitney test was performed to determine if the differences between the first and third administrations of the survey were significant. The initial group responses ($Mdn = 4$) did not differ significantly from the third administration of the survey ($Mdn = 4$), $U = 196.00$, $z = -1.38$, $p = .17$, $r = -.21$ (see Table 35). This represents a small to medium effect size.

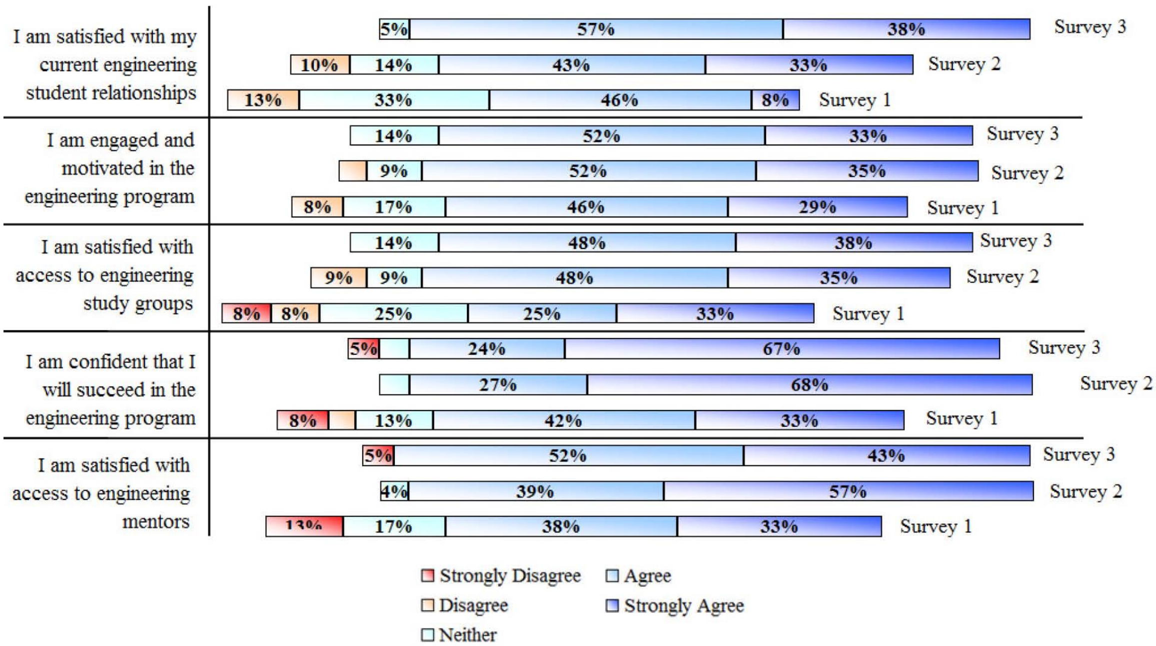

Figure 8. Diverging stacked bar chart: Treatment group responses for Survey 1, Survey 2, and Survey 3

Table 35
Treatment Group Response Statistics, Survey 1 to Survey 3

	Survey	*N*	Median	Mode	*U*	*z*	Sig.	*r*
Question 1	Survey 1	24	4	4	196.00	-1.38	.169	-.21
Access to mentors	Survey 3	21	4	4				
	Total	45						
Question 2	Survey 1	24	4	4	163.50	-2.19	.029*	-.33
Confidence	Survey 3	21	5	5				
	Total	45						
Question 3	Survey 1	24	4	5	193.00	-1.41	.158	-.21
Access to study groups	Survey 3	21	4	4				
	Total	45						
Question 4	Survey 1	24	4	4	222.00	-.740	.459	-.11
Motivation	Survey 3	21	4	4				
	Total	45						
Question 5	Survey 1	24	4	4	115.00	-3.38	.001*	-.50
Student relationships	Survey 3	21	4	4				
	Total	45						

* $p \leq .05$

Thus, the surveys revealed the Engineering TLC program was effective in providing mentoring opportunities. The first semester in the program was found to be significantly effective. The second semester, though not statistically significant, continued to find that nearly all students were satisfied with the program's ability to provide mentoring opportunities.

Interview results.

Engineering TLC participants expressed positive experiences from the program's mentoring opportunities (see Figure 9). Students found the program to be helpful in providing access to advisors and mentors. For example, James indicated, "it was nice to meet mentors from industry." Robert agreed by stating, "[the program] provided access to mentors and advisors, which helped keep me interested in engineering." Access to mentors was a common theme. Mary stated, "the program allowed us to consistently see

our advisor, which helped." William indicated, "[the program] got me in touch with my advisor," and Michael said, "[the program] helped with access to mentors." David summarized by stating, "[because of the program], I now know my advisors and when they are available." In sum, students felt the Engineering TLC improved access to mentors and advisors.

Figure 9. Wordle.com analysis for treatment group mentoring opportunities. This figure illustrates the most common word responses

Students that did not participate in the Engineering TLC program expressed generally negative experiences regarding access to mentors (see Figure 10). They felt they were lacking guidance and often relied on their parents for help selecting classes. Most did not feel they had guidance regarding preparation for the engineering profession. For example, Charles stated, "I don't have a mentor, just some professors." Joseph said, "I only speak with my professors about a class, not the [engineering] profession." Linda indicated, "I didn't get help from anyone at the college; my parents guided me." Thus,

students that did not participate in the Engineering TLC program felt they were lacking career guidance.

Figure 10. Wordle.com analysis for control group mentoring opportunities. This figure illustrates the most common word responses

In sum, the Engineering TLC program was effective in providing mentoring opportunities. Nearly all students were satisfied with the program's ability to provide mentoring. Students felt the program improved access to mentors and advisors. This is a sharp contrast to students that did not participate in the Engineering TLC program, who felt they were lacking career guidance.

Research Question 5: How effective is the Engineering TLC program in providing opportunities for student engagement and motivation?

The effectiveness of the Engineering TLC program to provide opportunities for student engagement and motivation was assessed using survey data and interviews. Survey data were used to compare changes in student responses after exposure in the Engineering TLC program. The interviews were used to investigate student experiences

in the Engineering TLC program.

Survey results.

Engagement and motivation.

Survey data were used to examine changes in student responses after one and two semesters in the Engineering TLC program. Initial survey results for engagement and motivation found 75% of the treatment group were engaged, and 8% were not engaged. A second administration of the survey (after one semester in the Engineering TLC program) found 87% were engaged, and 4% were not engaged (see Figure 7). A non-parametric Mann-Whitney test was performed to determine if the differences were significant. The initial group responses ($Mdn = 4$) did not differ significantly from the second administration of the survey ($Mdn = 4$), $U = 241.00$, $z = -.81$, $p = .42$, $r = -.12$ (see Table 34). This represents a small effect size.

The third administration of the survey (after two semester in the Engineering TLC program) found 85% of students were engaged, and 0% were not engaged (see Figure 8). A non-parametric Mann-Whitney test was performed to determine if the differences between the first and third administrations of the survey were significant. The initial group responses ($Mdn = 4$) did not differ significantly from the third administration of the survey ($Mdn = 4$), $U = 222.00$, $z = -.74$, $p = .46$, $r = -.11$ (see Table 35). This represents a small effect size.

Confidence.

Several studies found confidence was tied to student engagement and motivation. Eris et al, (2010) found engagement increased motivation to study engineering, and improved student confidence. In addition, Bourdon and Carducci (2002) found a

personal learning environment engaged students and improved confidence. Thus, confidence can be an indicator of student engagement and motivation. Hence, survey data for confidence were used to examine student engagement and motivation.

Initial survey results for confidence found 75% of the treatment group were confident, and 13% were not confident. A second administration of the survey (after one semester in the Engineering TLC program) found 95% were confident, and 0% were not confident (see Figure 7). A non-parametric Mann-Whitney test was performed to determine if the differences were significant. The initial group responses (*Mdn* = 4) did differ significantly from the second administration of the survey (*Mdn* = 5), *U* = 157.50, *z* = -2.57, *p* = .01, *r* = -.38 (see Table 34). This represents a medium to large effect size.

The third administration of the survey (after two semester in the Engineering TLC program) found 91% of students were confident, and 5% were not confident (see Figure 8). A non-parametric Mann-Whitney test was performed to determine if the differences between the first and third administrations of the survey were significant. The initial group responses (*Mdn* = 4) did differ significantly from the third administration of the survey (*Mdn* = 5), *U* = 163.50, *z* = -2.19, *p* = .03, *r* = -.33 (see Table 35). This represents a medium effect size.

Thus, the surveys found the Engineering TLC program was effective in providing engagement and motivation opportunities. Student confidence increased significantly in both the second and third administrations of the survey. Also, while not statistically significant, students indicated that their motivation and engagement increased after participation in the program.

Interview results.

Engineering TLC participants expressed positive experiences from the program's opportunities for student engagement and motivation (see Figure 11). Students indicated the program provided motivation, engagement, and improved confidence.

Figure 11. Wordle.com analysis for treatment group engagement and motivation. This figure illustrates the most common word responses

Several students stated they felt more motivated after participating in the program. For example, James said, "having guest speakers was really motivating." Michael felt, "meeting engineers and taking trips were very motivating." Also William stated, "[the program] increased my motivation by [helping me] learn about engineering and the profession." David summarized by stating, "I am now really motivated; I can see what I can expect to find being an engineer." James agreed by stating, "[the program] gave me a light at the end of the tunnel."

Students also expressed improved engagement. Mary said, "[the program] gave me direction." William agreed and stated, "it helped me understand where I was headed and where I am going." Robert found, "it definitely helped with finding a goal." Michael felt he, "knows more people now, and knows where to go for help." David stated that,

"[the program] boosted my success; I am now doing better in my engineering classes." John felt the program, "helped me identify a field of interest."

Many students felt the Engineering TLC program improved their confidence. Michael said, "[the program] made me more comfortable." John, William, and Mary each felt more confident. Mary stated, "[the program] made engineering seem less intimidating." John summarized by stating, "I am now more confident; I now know how to be successful, and know this is what I want to do." John also stated, "I would not have known what I was getting into if it weren't for the learning community."

Students that did not participate in the Engineering TLC program expressed generally negative experiences regarding engagement and motivation (see Figure 12). They described themselves as generally unconfident, unmotivated, and disorganized. For example Charles said, "my parents want me to do better, so that's my motivation." Linda answered similarly by stating, "my parents push me to be an engineer." Student confidence was generally poor. Richard indicated, "I think I'll be okay." Charles felt that, "if I organize my time better, I'll be fine." Joseph felt, "I think I can do this," and Richard stated his confidence, "was so-so."

Figure 12. Wordle.com analysis for control group engagement and motivation. This figure illustrates the most common word responses

In sum, the Engineering TLC program was effective in providing engagement and motivation opportunities. Student confidence increased significantly, and motivation and engagement increased after participation in the program. Students that did not participate in the Engineering TLC program expressed generally negative experiences regarding engagement and motivation and described themselves as generally unconfident, unmotivated, and disorganized.

Research Question 6: How effective is the Engineering TLC program in providing a sense of community?

The effectiveness of the Engineering TLC program to provide a sense of community was assessed using survey data and interviews. Survey data were used to compare changes in student responses after exposure in the Engineering TLC program. The interviews were used to investigate student experiences in the Engineering TLC program.

Survey results.

Student relationships.

Survey data were used to examine changes in student responses after one and two semesters in the Engineering TLC program. Initial survey results for student relationships found 54% of the treatment group were satisfied, and 13% were not satisfied. A second administration of the survey (after one semester in the Engineering TLC program) found 76% were satisfied, and 10% were not satisfied (see Figure 7). A non-parametric Mann-Whitney test was performed to determine if the differences were significant. The initial group responses ($Mdn = 4$) did differ significantly from the second administration of the survey ($Mdn = 4$), $U = 170.50$, $z = -1.97$, $p = .05$, $r = -.29$

(see Table 34). This represents a medium effect size.

The third administration of the survey (after two semester in the Engineering TLC program) found 95% of students were satisfied, and 0% were not satisfied (see Figure 8). A non-parametric Mann-Whitney test was performed to determine if the differences between the first and third administrations of the survey were significant. The initial group responses (*Mdn* = 4) did differ significantly from the third administration of the survey (*Mdn* = 4), $U = 115.00$, $z = -3.38$, $p = .00$, $r = -.50$ (see Table 35). This represents a large effect size.

Access to study groups.

Access to study groups was also used assess the Engineering TLC program's ability to provide a sense of community. Initial survey results for access to study groups found 58% of the treatment group were satisfied, and 16% were not satisfied. A second administration of the survey (after one semester in the Engineering TLC program) found 83% were satisfied, and 9% were not satisfied (see Figure 7). A non-parametric Mann-Whitney test was performed to determine if the differences were significant. The initial group responses (*Mdn* = 4) did not differ significantly from the second administration of the survey (*Mdn* = 4), $U = 229.00$, $z = -1.05$, $p = .29$, $r = -.15$ (see Table 34). This represents a small effect size.

The third administration of the survey (after two semester in the Engineering TLC program) found 86% of students were satisfied, and 0% were not satisfied (see Figure 8). A non-parametric Mann-Whitney test was performed to determine if the differences between the first and third administrations of the survey were significant. The initial group responses (*Mdn* = 4) did not differ significantly from the third administration of the

survey (*Mdn* = 4), $U = 193.00$, $z = -1.41$, $p = .16$, $r = -.21$ (see Table 35). This represents a small to medium effect size.

Thus, the surveys found the Engineering TLC program was effective in providing a sense of community. Student relationships increased significantly in both the second and third administrations of the survey, with a medium to large effect size. Also, while not statistically significant, students indicated that their access to study groups increased after participation in the program.

Interview results.

Engineering TLC participants expressed positive experiences from the program's ability to provide a sense of community (see Figure 13). Students indicated the program provided opportunities to make new friends and meet others with shared interests. For example, John said, "I met other students that have the same interests as I have." James stated, "[the program] allowed me to see who else was like-minded in our school, because I feel my age difference typically makes it tough to relate with other students." Robert agreed and indicated, "it was great to work with people that shared that same interests." Robert summarized by stating, "Being a commuter school, you don't interact with people on a daily basis, so it gave you a group of people you could talk to about things that you were interested in."

Figure 13. Wordle.com analysis for treatment group sense of community. This figure illustrates the most common word responses

Nearly all students interviewed expressed their pleasure with making new friends. For example, David said, "[the program] provided me with some friends that I can study with." Mary agreed and stated, "it builds friends; the more you work together, the more you become friends and want to study together." Michael indicated, "it helped getting to know people; it was a nice way to network." James summarized by stating, "it helped knowing people in your miniature community at the school; I now know people in my classes better." David felt, "[the program] provided a bond between us; we now know each other and can work together."

Students that did not participate in the Engineering TLC program expressed generally negative experiences regarding a sense of community (see Figure 14). These students often studied alone because they felt they did not know students in their classes. For example, Richard said, "I haven't worked in study groups, but I know they are available." Charles stated, "I never study in groups because I only see other people in class, so I don't really know them." Linda felt the same way, indicating, "I don't know people in my class, so I just study on my own." Joseph summarized by stating, "I can get

together with other students if I wanted, but it is not always easy reaching out to someone."

Figure 14. Wordle.com analysis for control group sense of community. This figure illustrates the most common word responses

In sum, the Engineering TLC program was effective in providing a sense of community. Student relationships increased significantly and students indicated that their access to study groups increased after participation in the program. Participants indicated the program provided opportunities to make new friends and meet others with shared interests. Students that did not participate in the Engineering TLC program expressed generally negative experiences regarding a sense of community, and often studied alone because they felt they did not know students in their classes.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Purpose Statement and Research Questions

The purpose of this study was to investigate whether community college student success and engagement was tied to participation in an engineering learning community at a northeastern community college. The following research questions were used to guide the study:

1. What is the relationship between course success and participation in the Engineering TLC program?

    1a. What is the relationship between course success and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

2. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program?

    2a. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

3. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program?

    3a. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

4. How effective is the Engineering TLC program in providing mentoring opportunities?
5. How effective is the Engineering TLC program in providing opportunities for student engagement and motivation?
6. How effective is the Engineering TLC program in providing a sense of community?

Findings Related to the Literature

This study found students that participated in the Engineering TLC program experienced a significant improvement in grade point values for one of the three post-test courses studied. This agrees with Fischer, Bol, and Pribesh (2011) who observed higher grade point averages for students that participated in small learning communities.

In addition, Budny, Paul, and Newborg (2010) found students that participated in learning communities experienced an overall increase in grade point averages. However, when confounding variables were considered in this study (engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status), the analyses revealed no significant relationship between course success and participation in the Engineering TLC program. Thus, the confounding variables provided alternative explanations for results of the three post-test courses results. In particular, age was found to be a significant factor in predicting grade point values for one of the three post-test courses studied. This agrees with Wolfle (2012), who found age was a significant factor for determining the success of college students. In fact, Wolfle found that an older nontraditional-age student was 136% more likely to succeed than a traditional-age student. It is also noted that the post-test grade point values may have experienced the

ceiling effect, which refers to the level at which an independent variable no longer has an effect on a dependent variable. For this study the Engineering TLC program (independent variable) may have had little effect on post-test grade point values (dependent variables), because the mean grade point values for both the control and treatment groups were relatively high.

The analysis revealed the odds of fall-to-spring retention were 5.02 times higher for students that participated in the Engineering TLC program. This agrees with ACT (2008), who found student involvement improved college retention. In addition, Hendriksen and Yang (2005) found tutored students achieved higher short-term retention. Also, Bourdon and Carducci (2002), found project led instruction in engineering increased student retention. However, when confounding variables were considered in this study (engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status), the analysis revealed students that participated in the Engineering TLC program were just as likely to re-enroll in spring classes as students in the control group. Again, the confounding variables provided alternative explanations for results of fall-to-spring retention. For example, part-time enrollment in college has been found to lower retention and student persistence (Forman, 2009).

The study found the odds of graduating or transferring were 4.9 times higher for students that participated in the Engineering TLC program. This agrees with Fischer, Bol, and Pribesh (2011), who found small learning communities often increase graduation rates. Also, Tinto (2003) found students were more likely to graduate in settings that provide academic, social, and personal support. Bailey, Calcagno, Jenkins, Kienzl, and Leinbach (2005) also found students graduate at higher rates in small,

personalized environments. Finally, Bourdon and Carducci (2002) found students who received peer mentoring graduated at higher rates than students that did not receive peer mentoring. However, when confounding variables were considered in this study (engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status), there was no significant association between participation in the Engineering TLC program and graduation/transfer. The confounding variables provided alternative explanations for results of graduation/transfer. In particular, full-time/part-time status has been found to impact graduation rates at community colleges. Approximately two-thirds of all community college students attend primarily on a part-time basis (Berkner, Horn, & Clune, 2000). Therefore, it takes them longer to complete college degrees than the typical time expected. As a result, graduation rates for engineering students at community colleges experience unique challenges related to the population that they serve. The study findings agree with Scrivener et al. (2008) who found that while learning communities improved students' experiences in college, long term effects such as improved graduation rates were not observed. Bryk, Gomez, and Grunow (2011) agree and found graduation rates in community colleges were an aggregate consequence of numerous processes, thus graduation rates were a result of interconnected components.

The Engineering TLC program was effective in providing mentoring opportunities. Nearly all students were satisfied with the program's ability to provide mentoring. Students felt the program improved access to mentors and advisors. This is important given that Eris et al. (2010) found mentor influence to be a strong motivator for students to study engineering. In fact, Brown, Hansen-Brown, and Conte (2011) found the single-most important factor in students' degree attainment was a positive mentoring

experience. This agrees with Lundberg (2014), who found frequent interaction with faculty mentors was the strongest predictor for student success. This study also found students that did not participate in the Engineering TLC program felt they were lacking career guidance. This agrees with Eris et al. (2010) who found non-persisting students were typically guided by parents, whereas persisting students are guided by mentors.

The Engineering TLC program was effective in providing engagement and motivation opportunities. Student confidence, motivation, and engagement increased after participation in the program. This agreed with Wasburn and Miller (2004) who found learning communities engaged students who typically viewed college as daunting and lonely. Student engagement has been found to improve self confidence (ACT, 2008). Bourdon and Carducci (2002) found personal learning environments improved student confidence. Hence, motivation and confidence have been found to predict interest and persistence in engineering programs (Cech, Rubineau, Silbey, & Seron, 2011).

The Engineering TLC program was effective in providing a sense of community. Student relationships increased significantly and access to study groups increased after participation in the program. Participants indicated the program provided opportunities to make new friends and meet others with shared interests. This agrees with Doolen and Biddlecombe (2014) who found participation in learning communities was linked to more positive student attitudes towards engineering. In fact, Laanan, Jackson and Stebleton (2013) found nearly 90% of learning community students viewed themselves as part of a campus community, and over 91% felt a sense of belonging with the college.

In sum, the results of this study support the conceptual framework. The conceptual framework sought to maximize student involvement to improve student

development, encourage student interactions as socializing agents, and utilize shared learning and discovery.

Implications for Policy and Practice

The results of the study have implications for policy and practice. Since the Engineering TLC program was found to be effective, it can serve as a model for other community college engineering programs. The primary goals should be to build a supportive environment, and provide guidance and encouragement throughout an engineering student's program of study. Students must be connected with one another to form study groups and forge friendships. It is critical that faculty send a positive message early (Starobin & Laanan, 2008). Both cognitive and non-cognitive domains of student performance should be incorporated into an institutional intervention to improve the low graduation rates for engineers. Specifically, cognitive domain indicators such as course success, retention, and graduation/transfer should be included. In addition, non-cognitive domain indicators such as mentoring, engagement and motivation, providing a sense of community, and instilling student confidence should be included. With proper implementation, engineering student success at community colleges can improve, and may result in an increase in undergraduate students obtaining degrees in engineering. This will help provide a workforce that can ensure a healthy economy through technological advancements and maintain America's creativity and international competitiveness (Bracey, 2008; Schoenfeld, 2003).

Recommendations for Future Research

This study did have limitations which provide an opportunity for future research. The study focused on an engineering learning community at a northeastern community

college. The engineering learning community program duration was one academic year. The study considered several confounding variables in some of its research questions.

A multi-year longitudinal study is recommended to better assess course success, retention, and graduation/transfer for students participating in a community college engineering learning community. In addition, it may be helpful to assess community college engineering learning communities in other geographic regions of the country. Finally, based on the confounding variables considered, there was some evidence that demographic factors may be tied to student success, both in terms of knowledge and engagement. It is suggested that additional study questions be investigated to examine demographic factors, participation in a community college engineering learning community, and student success.

Concluding Remarks

As a licensed professional engineer, the author feels strongly that increasing the number of undergraduate students obtaining degrees in engineering and technology will provide a workforce that is prepared to ensure a healthy economy through technological advancements. Low engineering graduation rates must be addressed. Interestingly, a small change in how we teach can make a big difference. As Barr and Tagg (1995) have stated:

> The change that is required to address today's challenges is not vast or difficult or expensive. It is a small thing. But it is a small change that changes everything. Simply ask, how would we do things differently if we put learning first? Then do it (p. 17).

This study attempted to engage community college engineering students. The engineering learning community experienced a degree of success. However, it is now apparent that more needs to be done to engage under-represented groups in engineering. The author is now acutely aware of the importance of scheduling activities to correspond with bus schedules and consider students' work schedules. Diverse role models must be utilized as guest speakers, adjunct professors, and mentors to illuminate the path to engineering. Hence, while this study is concluding, the task ahead is just beginning.

CHAPTER 6

ENGAGING COMMUNITY COLLEGE STUDENTS USING AN ENGINEERING LEARNING COMMUNITY

Overview of the Problem

There is a strong need to develop future engineers and technicians. Burkhardt and Schoenfeld (2003) have argued that increasing the number of undergraduate students obtaining degrees in engineering and technology will provide a workforce that is prepared to ensure a healthy economy through technological advancements. The occupational outlook for engineers is favorable. Employment of engineers and technicians is expected to grow over the next decade with overall job opportunities expected to be good (U.S. Department of Labor, Bureau of Labor Statistics, 2014). The United States has approximately 1.6 million engineering jobs that pay $42 per hour in median wages (Wright, 2014). Every engineering occupation has experienced job growth, with an overall engineering job growth of seven percent (Wright, 2014). While the unemployment rate in the United States continues to hover around seven percent, it is less than two percent for engineers (Hicks, 2013). There are strong needs and opportunities for future engineers, however, only half the students entering United States universities as engineering majors complete degree requirements (Pearson & Miller, 2012; Wulf & Fisher, 2002). This poor completion rate can also be found at community colleges. Data indicate that although roughly 90% of community college students enroll with intentions of earning a credential or to transfer to a four-year university, only 39% had earned a certificate, associate’s degree, or bachelor’s degree within six years (Hoachlander, Sikora, & Horn, 2003).

To address the poor completion rates experienced in engineering programs, colleges have experimented with several institutional interventions. While each intervention has experienced varying results, some successful trends have been identified. These trends include providing a personal and collaborative learning environment, using tutors and peer reviews, replacing instruction with learning, and using project led education. All these trends can be incorporated into learning communities (Brown, Hansen-Brown, & Conte, 2011). Research has described the impressive benefits of small learning communities, including lower drop-out rates, increased graduation rates, and higher grade point averages (Fischer, Bol, & Pribesh, 2011).

Engineering learning communities have been found to engage and motivate students in a collaborative and supportive atmosphere by accelerating the faculty-student relationship (Borrego, Karlin, McNair, & Beddoes, 2013). Learning is stressed rather than instruction (Arms, Duerden, Green, Killingsworth, & Taylor, 1998). Nearly 90% of learning community students view themselves as part of a campus community, and over 91% say they feel a sense of belonging with the college (Laanan, Jackson, & Stebleton, 2013). Participation in learning communities has been linked to more positive student attitudes towards engineering and higher levels of student satisfaction with collaborative learning techniques (Doolen & Biddlecombe, 2014). While the benefits of an engineering learning community have been clearly documented in the literature, very few engineering learning communities exist in community colleges. Thus, this study bridged the gap in the literature by evaluating the impacts of a learning community on a community college engineering program.

To investigate whether community college engineering student success was tied

to a learning community, a pilot plan entitled “Engineering TLC: Tutors and Learning Communities” was implemented. Engineering TLC sought to establish mentoring opportunities, increase course success rates, increase student retention, increase student engagement and motivation, provide a sense of community, and increase graduation rates.

Purpose Statement and Research Questions

The purpose of this study was to investigate whether community college student success and engagement was tied to participation in an engineering learning community at a northeastern community college. The following research questions were used to guide the study:

1. What is the relationship between course success and participation in the Engineering TLC program?
    1a. What is the relationship between course success and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?
2. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program?
    2a. What is the relationship between fall-to-spring retention and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?
3. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program?

3a. What is the relationship between graduation/transfer rates and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status?

4. How effective is the Engineering TLC program in providing mentoring opportunities?
5. How effective is the Engineering TLC program in providing opportunities for student engagement and motivation?
6. How effective is the Engineering TLC program in providing a sense of community?

Review of the Methodology

Conceptual framework.

The conceptual framework for this study combined Astin's (1999) Student Involvement Theory, Pascarella's (1985) General Model for Assessing Change, and the Center for the Integration of Research, Teaching, and Learning's (CIRTL) learning community model (Pfund et al., 2012). According to Astin's (1999) Student Involvement Theory, "the greater the student's involvement in college, the greater will be the amount of learning and personal development" (p. 529). In addition, components of Pascarella's General Model for Assessing Change (1985) were utilized. In Pascarella's model, change is a function of students' background characteristics, interactions with major socializing agents, and the quality of the student's efforts in learning and developing (Pascarella, 1985). Finally, the CIRTL's learning community model brings together groups of people for shared learning and the discovery and generation of knowledge (Pfund et al., 2012).

Thus this study's conceptual framework sought to maximize student involvement to improve student development, encourage student interactions as socializing agents, and utilize shared learning and discovery. Both cognitive and non-cognitive domains of student performance were acknowledged as indicators for engineering student success. These domains, in turn, were incorporated into an institutional intervention to improve the low graduation rates for engineers. Specifically, an engineering learning community was used to address cognitive domain indicators such as course success, retention, and graduation/transfer. In addition, an engineering learning community was used to address non-cognitive domain indicators such as mentoring, engagement and motivation, providing a sense of community, and instilling student confidence.

Research design.

Since random assignment of sample groups was impractical, the most appropriate research design method to investigate engineering student success was the nonrandomized control group pretest-posttest design (Li, Swaminathan, & Tang, 2009). The nonrandomized control group pretest-posttest design can demonstrate that two groups are equivalent with respect to the dependent variables prior to treatment, thus eliminating initial group differences as an explanation for post-treatment differences (Leedy & Ormrod, 2013). While other possible explanations for the results cannot be ruled out, some alternative explanations can be eliminated. This study considered two groups: students who participated in the engineering learning community (treatment group) and students who did not participate in the engineering learning community (control group).

This study utilized both quantitative and qualitative methods to assess student success and engagement in the Engineering TLC program. Course success, student retention, and graduation/transfer rates were evaluated using quantitative methods. The remaining engagement goals were evaluated using qualitative methods.

For the qualitative portion of this study, the research tradition selected was a phenomenological design. A phenomenological design is used to understand an experience from the participant's point of view. A phenomenological design focuses on a particular phenomenon experienced by the participants (Leedy & Ormrod, 2013), such as engineering student's participation in the Engineering TLC program.

Population and sample.

The study population encompassed engineering students in the United States. This included students at community colleges that offer programs in engineering and civil engineering technology. The majority of civil engineering students are males (78%) (Gibbons, 2009). Demographic information for the population of civil engineering students in the United States indicate that 67% of students are white, 12% of students are Asian-American, 8.5% of students are Hispanic, and 4.2% of students are African-American (Gibbons, 2009). The population of engineering students in the nation is 81,382, which is the result of a steady enrollment decrease in sciences and engineering (Barry, 2009; National Center for Education Statistics, 2012).

The sample for this study was comprised of students in both the engineering science and civil engineering technology programs at a northeastern community college. Engineering science and civil engineering technology are separate but closely related programs. The majority of the northeastern community college sample engineering

students (84%) were males. Demographic information for the sample of community college engineering students indicated that 67% of students are white, 8% of students are Asian-Pacific Islander, 8% of students are Hispanic, and 8% of students are African-American. All engineering and engineering technology students were invited to participate in the Engineering TLC program. Students were invited via email, visits to their classrooms, and discussions during advisement sessions. All participants were 18 years of age or older.

The sample was suitable for this study since the demographic information was representative of the population. Also, the topic studied (the impacts of implementing an Engineering TLC program on student success and engagement) could be applied to the population of engineering students in the United States.

There were 93 full time engineering and engineering technology students at the community college. Thirty-eight students chose to participate in the Engineering TLC program, with the remaining students serving as the control group. Thus, a sample size of 93 students produced a confidence interval of 10.16%, for a confidence level of 95% and a population of 81,382 engineering students (Creative Research Systems, 2012). This sample size was large enough to conduct appropriate statistical analysis.

Instrumentation.

This study utilized both surveys and interviews to assess three project goals:

1. Establish mentoring opportunities
2. Increase student engagement and motivation
3. Provide a sense of community

Surveys.

A researcher designed survey assessed student perceptions of Engineering TLC at three milestones: prior to joining the learning community, after one semester in the learning community, and after two semesters in the learning community. The same survey also assessed perceptions of the control group at the beginning of the first semester. Thus, the first survey assessed whether the control group and the treatment group were similar prior to treatment, while the second and third surveys assessed treatment group changes after participation in the learning community. All members of the Engineering TLC were asked to participate in the project surveys. The same survey was used at each milestone, to detect response changes over time. The survey investigated student perceptions involving presence of mentors, confidence, study group access, engagement and motivation, and peer relationships.

To assess student perceptions of the Engineering TLC program, Likert scale questions were used. Five ordered response levels were used for each question. This scale measured the positive or negative responses to each question. These results were used to both compare the treatment group to the control group, and the variation of treatment group responses over time.

Demographic information was collected as part of the survey instrument. This provided a breakdown of response data into meaningful groups of respondents. The demographic information was used to both compare the treatment group to the control group, and the sample to the population. Demographic information collected included age, gender, ethnicity, full-time or part-time student status, and Pell grant participation.

The survey concluded with two open ended questions. The open ended questions gave the respondent an opportunity to provide a range of answers that may not have been initially considered. This allowed for more depth and insight into student perception of the Engineering TLC program. The open ended questions inquired why students chose to join the program and how the program could be improved to meet their needs.

Interviews.

At the conclusion of the year-long engineering learning community, eleven student interviews were conducted; seven treatment group interviews, and four control group interviews. Selective sampling was used to allow consideration of gender and engineering major in the interview results. The survey investigated student perceptions involving presence of mentors, confidence, study group access, engagement and motivation, and peer relationships.

A pilot test was used to assess the interview questions. This allowed identification of flaws, limitations, or other weaknesses within the interview and for necessary revisions prior to implementation of the study. The pilot test was conducted by five recent engineering graduates.

The interviews provided an opportunity to give voice to students participating in the Engineering TLC program using in-depth observations and one-on-one interviews. The transcribed interviews were reviewed by another community college professor to identify agreement regarding patterns and concepts that emerged. This bracketing verification removed interviewer personal beliefs and knowledge from the study.

Data collection.

This study utilized three separate data collection sources: surveys, interviews, and existing student records. The surveys were administered at three milestones: prior to joining the learning community, after one semester in the learning community, and after two semesters in the learning community. At the conclusion of the program, eleven student interviews were conducted; seven treatment group interviews, and four control group interviews. Finally, existing data was used to assess course success, retention, and graduation/transfer rates at the conclusion of the program.

Surveys.

Survey information was collected using online questionnaires (see Appendix D). The surveys were sent via email to all engineering students. All students that participated in the Engineering TLC program were required to complete the surveys, while those students not participating (the control group) were asked to complete the surveys. Surveys were administered at three milestones: prior to joining the learning community, after one semester in the learning community, and after two semesters in the learning community. Survey responses were anonymous and confidential.

Interviews.

At the conclusion of the year-long engineering learning community, eleven students were interviewed; seven from the treatment group, and four from the control group. Selective sampling was used to allow consideration of gender and engineering major in the interview results. The interviews were conducted in the college's engineering laboratory after the student's regularly scheduled class. Students were interviewed individually, with no other students or faculty present for the interview. All participants

were 18 years of age or older. After approval by the student, an audio recorder was used to assist with data collection

Participation in the interview was voluntary. Information gathered in this study was confidential. A pseudonym was used to provide anonymity. Students had the right to review and comment on information prior to the study's completion.

Existing student records.

Course success, student retention, and graduation/transfer rates were evaluated using quantitative statistical methods as summative measures. The information required to complete the statistical analysis was obtained from the community college's office of Institutional Research, Assessment and Planning. Existing data was anonymous and confidential. The results were aggregated and any identifying information was removed.

Data analysis.

Surveys.

Likert response items were used to assess the majority of the questions on the survey. Likert items have a rank order, but the intervals between values cannot be presumed equal (Jamieson, 2004). Therefore, the measures of central tendency that are appropriate for ordinal data are median and mode, rather than mean and standard deviation (Jamieson, 2004). The Likert responses were reported as bar charts, and tables with median and mode. The remaining demographic and open-ended information collected was reported using tables. Finally, non-parametric Mann-Whitney tests were performed to determine if response differences were significant.

Interviews.

The interview information was analyzed using the six phases of data analysis outlined by Marshall and Rossman (1999): generating categories, themes, and patterns; coding the data; testing the emergent understandings; searching for alternative explanations; and writing the report. The data were organized through multiple readings of the text, including field notes, observations, and reflections. When continued review produced no new descriptive values, categories were defined as sufficiently well-represented, or 'saturated' (Meyer & Schwitzer, 1999).

Inter-rater reliability was used improve interpretation consistency. The transcribed interviews were reviewed by another community college professor to identify agreement regarding patterns and concepts that emerged. The other college professor serves in a separate division than the author, and is of equal rank to the author, thus there are no power issues regarding reporting structure between the two reviewers.

Existing student records.

Composite pre-test scores were developed for the control and treatment groups by considering grade point values for: pre-calculus, English 1, and Physics 1. The goal was to show that the two groups were equivalent prior to the treatment (participation in the Engineering TLC program). The independent variable (Engineering TLC participation) had a nominal measurement scale, and the dependent variables (grade point values) had interval measurement scales. Therefore, the appropriate analysis method for the pre-test assessment was an independent *t*-test.

The two groups were then compared after the treatment by examining subsequent course success (grade point values), student retention, and graduation/transfer rates. The

goal was to show post-treatment differences while eliminating initial group differences as an explanation. The posttest assessment of grade point values had interval measurement scale. Therefore, the appropriate analyses method was an independent *t*-test. The assessment of retention and graduation/transfer had nominal measurement scales. Therefore, the appropriate analysis methods for these variables were Chi square tests and logistic regression.

The two groups were then compared after the treatment by examining subsequent course success (grade point values), student retention, and graduation/transfer rates, along with several confounding variables. The confounding variables were engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time student. Therefore, the appropriate analyses methods for post-test assessment was a factorial ANCOVA when examining grade point values, and logistic regression when examining retention and graduation/transfer.

Critique of the Study Design

This study bridged the gap in the literature by assessing an engineering learning community at a community college. Community colleges are essential to the education of engineers in the United States (Sislin & Mattis, 2005). Community college students that complete an associate of science degree in engineering are just as likely to receive a bachelor's degree as students who attend four-year campuses only (Sislin & Mattis, 2005). In fact, 20% of engineering degree holders began their academic careers at community colleges (Sislin & Mattis, 2005). Engineering learning communities have been found to engage and motivate students in a collaborative and supportive atmosphere by accelerating the faculty-student relationship (Borrego, Karlin, McNair, & Beddoes,

2013). While engineering learning communities have been found to be an effective educational practice, few have been implemented in community colleges. This study evaluated the effectiveness of a learning community on an engineering program at a northeastern community college.

This study's conceptual framework sought to maximize student involvement to improve student development, encourage student interactions as socializing agents, and utilize shared learning and discovery. Both cognitive and non-cognitive domains of student performance were acknowledged as indicators for engineering student success. These domains, in turn, were incorporated into an institutional intervention to improve the low graduation rates for engineers. Specifically, an engineering learning community was used to address cognitive domain indicators such as course success, retention, and graduation/transfer. In addition, an engineering learning community was used to address non-cognitive domain indicators such as mentoring, engagement and motivation, providing a sense of community, and instilling student confidence.

Both quantitative and qualitative methods were used to assess student success and engagement in the Engineering TLC program. Course success, student retention, and graduation/transfer rates were evaluated using quantitative methods. Qualitative methods were used to assess goals related to establishing mentoring opportunities, increasing student engagement and motivation, and providing a sense of community. This mixed methods approach allowed a complimentary relationship between qualitative and quantitative data, one clarifying the other. The study benefitted from a mixed methods approach by providing stronger evidence for a conclusion through convergence and corroboration of findings, which increased generalizability of results and produced a

more complete knowledge to inform theory and practice (Johnson & Onwuegbuzie, 2004).

A quasi-experimental design was used for this study. Specifically, a nonrandomized control group pretest-posttest design was used to demonstrate that two groups were equivalent with respect to the dependent variables prior to treatment. The initial group comparison (pre-test) considered both the non-cognitive and cognitive domains. The initial survey responses were used to assess the non-cognitive domain, and the composite pre-test scores for pre-calculus, English 1, and Physics 1 were used to assess the cognitive domain. A comparison of the control and treatment groups prior to participation in the engineering learning community showed that the two groups were equivalent with respect to the dependent variables, considering both cognitive and non-cognitive domain indicators. Thus, initial group differences could be eliminated as an explanation for post-treatment differences.

Confounding variables were considered in the first three research questions. The confounding variables considered were engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status. Confounding variables provide alternative explanations for results, which threaten internal validity (Sprinthall, 2012). Thus, the internal validity of this study was improved by considering confounding variables that could influence the outcome of the study.

Summary of Major Findings

Group Comparison Prior to Treatment.

The research design method used in this study was the nonrandomized control group pretest-posttest design. This design can demonstrate that if the two groups are

equivalent with respect to the dependent variable prior to treatment, initial group differences can be eliminated as an explanation for post-treatment differences (Leedy & Ormrod, 2013). The goal, therefore, was to show that the control and treatment groups were equivalent prior to treatment. The initial group comparison considered both the non-cognitive and cognitive domains. The initial survey responses were used to assess the non-cognitive domain, and the composite pre-test scores for pre-calculus, English 1, and Physics 1 were used to assess the cognitive domain.

Non-cognitive domain.

The survey responses investigated student access to engineering mentors, confidence, access to study groups, engagement and motivation, relationships. Non-parametric Mann-Whitney tests were performed to determine if the differences were significant. The control and treatment groups were found to be equivalent prior to treatment considering the non-cognitive domain indicators.

Survey results for access to engineering mentors found 72% of the control group were satisfied, and 3% were not satisfied. The treatment group survey found 71% were satisfied, and 13% were not satisfied. The control group access to engineering mentors did not differ significantly from the treatment group (p = .88).

Survey results for confidence found 93% of the control group were confident, and 3% were not confident. The treatment group survey found 75% were confident, and 13% were not confident. While the control group reported a higher confidence level than the treatment group, the control group confidence did not differ significantly from the treatment group (p = .34).

Survey results for access to engineering study groups found 54% of the control

group were satisfied, and 3% were not satisfied. The treatment group survey found 58% were satisfied, and 17% were not satisfied. The control group access to study groups did not differ significantly from the treatment group (p = .71).

Survey results for engagement and motivation found 82% of the control group were satisfied, and 3% were not satisfied. The treatment group survey found 75% were satisfied, and 8% were not satisfied. The control group engagement and motivation did not differ significantly from the treatment group (p = .88).

Lastly, survey results for student relationships found 61% of the control group were satisfied, and 7% were not satisfied. The treatment group survey found 54% were satisfied, and 13% were not satisfied. The control group student relationships did not differ significantly from the treatment group (p = .40). Thus, the control and treatment groups were equivalent prior to treatment considering the non-cognitive domain indicators.

Cognitive domain.

The composite pre-test scores considered the cognitive domain by examining grade point values for pre-calculus, English 1, and Physics 1. An independent t-test was used to examine grade point values for each of the three pre-test courses. The control and treatment groups were found to be equivalent prior to treatment considering the cognitive domain indicators.

Pre-calculus grade point values for the treatment group did not differ significantly from the control group (p = .72). English 1 grade point values for the treatment group did not differ significantly from the control group (p = .07). Finally, Physics 1 grade point values for the treatment group did not differ significantly from the control group

(p = .56). Hence, the control and treatment groups were equivalent prior to treatment considering the cognitive domain indicators.

In sum, a comparison of the control and treatment groups prior to participation in the engineering learning community showed that the two groups were equivalent with respect to the dependent variables, considering both cognitive and non-cognitive domain indicators. Thus, initial group differences can be eliminated as an explanation for post-treatment differences.

The Research Questions.

The first research question was, "What is the relationship between course success and participation in the Engineering TLC program?" The post-test scores examined grade point values for statics, mechanics of materials, and Physics 2. An independent *t*-test was used to examine grade point values for each of the three post-test courses. Mechanics of materials grade point values for the treatment group did differ significantly from the control group (p = .04), and produced a medium effect size. Statics grade point values for the treatment group did not differ significantly from the control group (p = .07), and produced a small to medium effect size. Finally, Physics 2 grade point values for the treatment group did not differ significantly from the control group (p = .47), and produced a small effect size. Hence, the relationship between course success and participation in the Engineering TLC program is generally positive. Students that participated in the Engineering TLC program experienced a significant improvement in grade point value for one of the three post-test courses studied.

The first research question was also modified to consider several confounding variables. The confounding variables were engineering major, age, Pell Grant

participation, gender, ethnicity, and full-time/part-time status. An analysis of covariance (ANCOVA) was used to examine grade point values for each of the three post-test courses. Statics grade point values were not significantly related to participation in the Engineering TLC program when considering the confounding variables (p = .14), and produced a small effect size. Mechanics of materials grade point values were not significantly related to participation in the Engineering TLC program when considering the confounding variables (p = .10), and produced a small effect size. Lastly, Physics 2 grade point values were not significantly related to participation in the Engineering TLC program when considering the confounding variables (p = .52), and produced a small effect size. Thus, the analyses revealed no significant relationship between course success and participation in the Engineering TLC program considering engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status as confounding variables.

The second research question was, "What is the relationship between fall-to-spring retention and participation in the Engineering TLC program?" This relationship was examined using both a chi-square test and logistic regression. The chi-square test revealed a significant association between participation in the Engineering TLC program and fall-to-spring retention (p = .03). Logistic regression also yielded a significant association between participation in the Engineering TLC program and fall-to-spring retention (p = .04). Both analyses indicated that, based on the odds ratio, the odds of retention were 5.02 times higher for students that participated in the Engineering TLC program.

The second research question was also modified to consider several confounding

variables. The confounding variables were engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status. Logistic regression was used to investigate the relationship between fall-to-spring retention and participation in the Engineering TLC program considering the covariates. Logistic regression yielded no significant association between participation in the Engineering TLC program and fall-to-spring retention (*p* = .99). Students that participated in the Engineering TLC program were just as likely to re-enroll in spring classes as students in the control group. In fact, none of the confounding variables yielded a significant association with fall-to-spring retention.

The third research question was, "What is the relationship between graduation/transfer rates and participation in the Engineering TLC program?" This relationship was examined using both a chi-square test and logistic regression.
The chi-square test revealed a significant association between participation in the Engineering TLC program and graduation/transfer (*p* = .00). Logistic regression also yielded a significant a significant association between participation in the Engineering TLC program and graduation/transfer (*p* = .00). Both analyses indicated that, based on the odds ratio, the odds of graduating or transferring were 4.9 times higher for students that participated in the Engineering TLC program.

The third research questions was also modified to consider several confounding variables. The confounding variables were engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status. Logistic regression was used to investigate the relationship between graduation/transfer and participation in the Engineering TLC program considering the covariates. Logistic regression yielded no

significant association between participation in the Engineering TLC program and graduation/transfer (*p* = .06).

The fourth research question was, "How effective is the Engineering TLC program in providing mentoring opportunities?" This research question was assessed using survey data and interviews. Survey data were used to examine changes in student responses after one and two semesters in the Engineering TLC program. Initial survey results found 71% of the treatment group were satisfied, and 13% were not satisfied. A second administration of the survey (after one semester in the Engineering TLC program) found 96% were satisfied, and 0% were not satisfied. A Mann-Whitney test found the initial group responses did differ significantly from the second administration of the survey (*p* = .03), and produced a medium effect size. The third administration of the survey (after two semesters in the Engineering TLC program) found 95% of students were satisfied, and 5% were not satisfied. The initial group responses did not differ significantly from the third administration of the survey (*p* = .17), and produced a small to medium effect size. Thus, the surveys found the Engineering TLC program was effective in providing mentoring opportunities. The first semester in the program was found to be significantly effective. The second semester, though not statistically significant, continued to find that nearly all students were satisfied with the program's ability to provide mentoring opportunities. Finally, the interviews revealed the Engineering TLC program was effective in providing mentoring opportunities. Nearly all students were satisfied with the program's ability to provide mentoring. Students felt the program improved access to mentors and advisors. This is a sharp contrast to students that did not participate in the Engineering TLC program, who felt they were lacking

career guidance.

The fifth research question was, "How effective is the Engineering TLC program in providing opportunities for student engagement and motivation?" This research question was assessed using survey data and interviews. Survey data were used to examine changes in student responses after one and two semesters in the Engineering TLC program. Initial survey results for engagement and motivation found 75% of the treatment group were engaged, and 8% were not engaged. A second administration of the survey (after one semester in the Engineering TLC program) found 87% were engaged, and 4% were not engaged. A Mann-Whitney test found the initial group responses did not differ significantly from the second administration of the survey (p = .42), and produced a small size effect. The third administration of the survey (after two semesters in the Engineering TLC program) found 85% of students were engaged, and 0% were not engaged. The initial group responses did not differ significantly from the third administration of the survey (p = .46), and produced a small effect size. It has been shown that confidence is tied to student engagement and motivation (Eris et al, 2010). Hence, survey data for confidence were used to examine student engagement and motivation. Initial survey results for confidence found 75% of the treatment group were confident, and 13% were not confident. A second administration of the survey (after one semester in the Engineering TLC program) found 95% were confident, and 0% were not confident. The initial group responses did differ significantly from the second administration of the survey (p = .01) and produced a medium to large effect size. The third administration of the survey (after two semesters in the Engineering TLC program) found 91% of students were confident, and 5% were not confident. The initial group

responses did differ significantly from the third administration of the survey ($p = .03$), and produced a medium effect size. Thus, the surveys found the Engineering TLC program was effective in providing engagement and motivation opportunities. Student confidence increased significantly in both the second and third administrations of the survey. Also, while not statistically significant, students indicated that their motivation and engagement increased after participation in the program. Finally, the interviews revealed the Engineering TLC program was effective in providing engagement and motivation opportunities. Student confidence, motivation, and engagement increased after participation in the program. Students that did not participate in the Engineering TLC program expressed generally negative experiences regarding engagement and motivation and described themselves as generally unconfident, unmotivated, and disorganized.

The final research question was, "How effective is the Engineering TLC program in providing a sense of community?" This research question was assessed using survey data and interviews. Survey data were used to examine changes in student responses after one and two semesters in the Engineering TLC program. Initial survey results for student relationships found 54% of the treatment group were satisfied, and 13% were not satisfied. A second administration of the survey (after one semester in the Engineering TLC program) found 76% were satisfied, and 10% were not satisfied. A Mann-Whitney test found the initial group responses did differ significantly from the second administration of the survey ($p = .05$), and produced a medium effect size. The third administration of the survey (after two semesters in the Engineering TLC program) found 95% of students were satisfied, and 0% were not satisfied. The initial group responses

did differ significantly from the third administration of the survey (p = .00), and produced a large effect size. Access to study groups was also used assess the Engineering TLC program's ability to provide a sense of community. Initial survey results for access to study groups found 58% of the treatment group were satisfied, and 16% were not satisfied. A second administration of the survey (after one semester in the Engineering TLC program) found 83% were satisfied, and 9% were not satisfied. The initial group responses did not differ significantly from the second administration of the survey (p = .29), and produced a small effect size. The third administration of the survey (after two semesters in the Engineering TLC program) found 86% of students were satisfied, and 0% were not satisfied. The initial group responses did not differ significantly from the third administration of the survey (p = .16), and produced a small to medium effect size. Thus, the surveys found the Engineering TLC program was effective in providing a sense of community. Student relationships increased significantly in both the second and third administrations of the survey, with a medium to large effect size. Also, while not statistically significant, students indicated that their access to study groups increased after participation in the program. Finally, the interviews revealed the Engineering TLC program was effective in providing a sense of community. Participants indicated the program provided opportunities to make new friends and meet others with shared interests. Students that did not participate in the Engineering TLC program expressed generally negative experiences regarding a sense of community, and often studied alone because they felt they did not know students in their classes.

Findings Related to the Literature

This study found students that participated in the Engineering TLC program experienced a significant improvement in grade point values for one of the three post-test courses studied. This agrees with Fischer, Bol, and Pribesh (2011) who observed higher grade point averages for students that participated in small learning communities.
In addition, Budny, Paul, and Newborg (2010) found students that participated in learning communities experienced an overall increase in grade point averages. However, when confounding variables were considered in this study (engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status), the analyses revealed no significant relationship between course success and participation in the Engineering TLC program. Thus, the confounding variables provided alternative explanations for results of the three post-test courses results. In particular, age was found to be a significant factor in predicting grade point values for one of the three post-test courses studied. This agrees with Wolfle (2012), who found age was a significant factor for determining the success of college students. In fact, Wolfle found that an older nontraditional-age student was 136% more likely to succeed than a traditional-age student. It is also noted that the post-test grade point values may have experienced the ceiling effect, which refers to the level at which an independent variable no longer has an effect on a dependent variable. For this study the Engineering TLC program (independent variable) may have had little effect on post-test grade point values (dependent variables), because the mean grade point values for both the control and treatment groups were relatively high.

The analysis revealed the odds of fall-to-spring retention were 5.02 times higher

for students that participated in the Engineering TLC program. This agrees with ACT (2008), who found student involvement improved college retention. In addition, Hendriksen and Yang (2005) found tutored students achieved higher short-term retention. Also, Bourdon and Carducci (2002), found project led instruction in engineering increased student retention. However, when confounding variables were considered in this study (engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status), the analysis revealed students that participated in the Engineering TLC program were just as likely to re-enroll in spring classes as students in the control group. Again, the confounding variables provided alternative explanations for results of fall-to-spring retention. For example, part-time enrollment in college has been found to lower retention and student persistence (Forman, 2009).

The study found the odds of graduating or transferring were 4.9 times higher for students that participated in the Engineering TLC program. This agrees with Fischer, Bol, and Pribesh (2011), who found small learning communities often increase graduation rates. Also, Tinto (2003) found students were more likely to graduate in settings that provide academic, social, and personal support. Bailey, Calcagno, Jenkins, Kienzl, and Leinbach (2005) also found students graduate at higher rates in small, personalized environments. Finally, Bourdon and Carducci (2002) found students who received peer mentoring graduated at higher rates than students that did not receive peer mentoring. However, when confounding variables were considered in this study (engineering major, age, Pell Grant participation, gender, ethnicity, and full-time/part-time status), there was no significant association between participation in the Engineering TLC program and graduation/transfer. The confounding variables provided alternative

explanations for results of graduation/transfer. In particular, full-time/part-time status has been found to impact graduation rates at community colleges. Approximately two-thirds of all community college students attend primarily on a part-time basis (Berkner, Horn, & Clune, 2000). Therefore, it takes them longer to complete college degrees than the typical time expected. As a result, graduation rates for engineering students at community colleges experience unique challenges related to the population that they serve. The study findings agree with Scrivener et al. (2008) who found that while learning communities improved students' experiences in college, long term effects such as improved graduation rates were not observed. Bryk, Gomez, and Grunow (2011) agree and found graduation rates in community colleges were an aggregate consequence of numerous processes, thus graduation rates were a result of interconnected components.

The Engineering TLC program was effective in providing mentoring opportunities. Nearly all students were satisfied with the program's ability to provide mentoring. Students felt the program improved access to mentors and advisors. This is important given that Eris et al. (2010) found mentor influence to be a strong motivator for students to study engineering. In fact, Brown, Hansen-Brown, and Conte (2011) found the single-most important factor in students' degree attainment was a positive mentoring experience. This agrees with Lundberg (2014), who found frequent interaction with faculty mentors was the strongest predictor for student success. This study also found students that did not participate in the Engineering TLC program felt they were lacking career guidance. This agrees with Eris et al. (2010) who found non-persisting students were typically guided by parents, whereas persisting students are guided by mentors.

The Engineering TLC program was effective in providing engagement and

motivation opportunities. Student confidence, motivation, and engagement increased after participation in the program. This agreed with Wasburn and Miller (2004) who found learning communities engaged students who typically viewed college as daunting and lonely. Student engagement has been found to improve self confidence (ACT, 2008). Bourdon and Carducci (2002) found personal learning environments improved student confidence. Hence, motivation and confidence have been found to predict interest and persistence in engineering programs (Cech, Rubineau, Silbey, & Seron, 2011).

The Engineering TLC program was effective in providing a sense of community. Student relationships increased significantly and access to study groups increased after participation in the program. Participants indicated the program provided opportunities to make new friends and meet others with shared interests. This agrees with Doolen and Biddlecombe (2014) who found participation in learning communities was linked to more positive student attitudes towards engineering. In fact, Laanan, Jackson and Stebleton (2013) found nearly 90% of learning community students viewed themselves as part of a campus community, and over 91% felt a sense of belonging with the college.

In sum, the results of this study support the conceptual framework. The conceptual framework sought to maximize student involvement to improve student development, encourage student interactions as socializing agents, and utilize shared learning and discovery.

Implications for Policy and Practice

The results of the study have implications for policy and practice. Since the Engineering TLC program was found to be effective, it can serve as a model for other community college engineering programs. The primary goals should be to build a

supportive environment, and provide guidance and encouragement throughout an engineering student's program of study. Students must be connected with one another to form study groups and forge friendships. It is critical that faculty send a positive message early (Starobin & Laanan, 2008). Both cognitive and non-cognitive domains of student performance should be incorporated into an institutional intervention to improve the low graduation rates for engineers. Specifically, cognitive domain indicators such as course success, retention, and graduation/transfer should be included. In addition, non-cognitive domain indicators such as mentoring, engagement and motivation, providing a sense of community, and instilling student confidence should be included. With proper implementation, engineering student success at community colleges can improve, and may result in an increase in undergraduate students obtaining degrees in engineering. This will help provide a workforce that can ensure a healthy economy through technological advancements and maintain America's creativity and international competitiveness (Bracey, 2008; Schoenfeld, 2003).

Recommendations for Future Research

This study did have limitations which provide an opportunity for future research. The study focused on an engineering learning community at a northeastern community college. The engineering learning community program duration was one academic year. The study considered several confounding variables in some of its research questions.

A multi-year longitudinal study is recommended to better assess course success, retention, and graduation/transfer for students participating in a community college engineering learning community. In addition, it may be helpful to assess community college engineering learning communities in other geographic regions of the country.

Finally, based on the confounding variables considered, there was some evidence that demographic factors may be tied to student success, both in terms of knowledge and engagement. It is suggested that additional study questions be investigated to test for interactions between demographic factors, participation in a community college engineering learning community, and student success.

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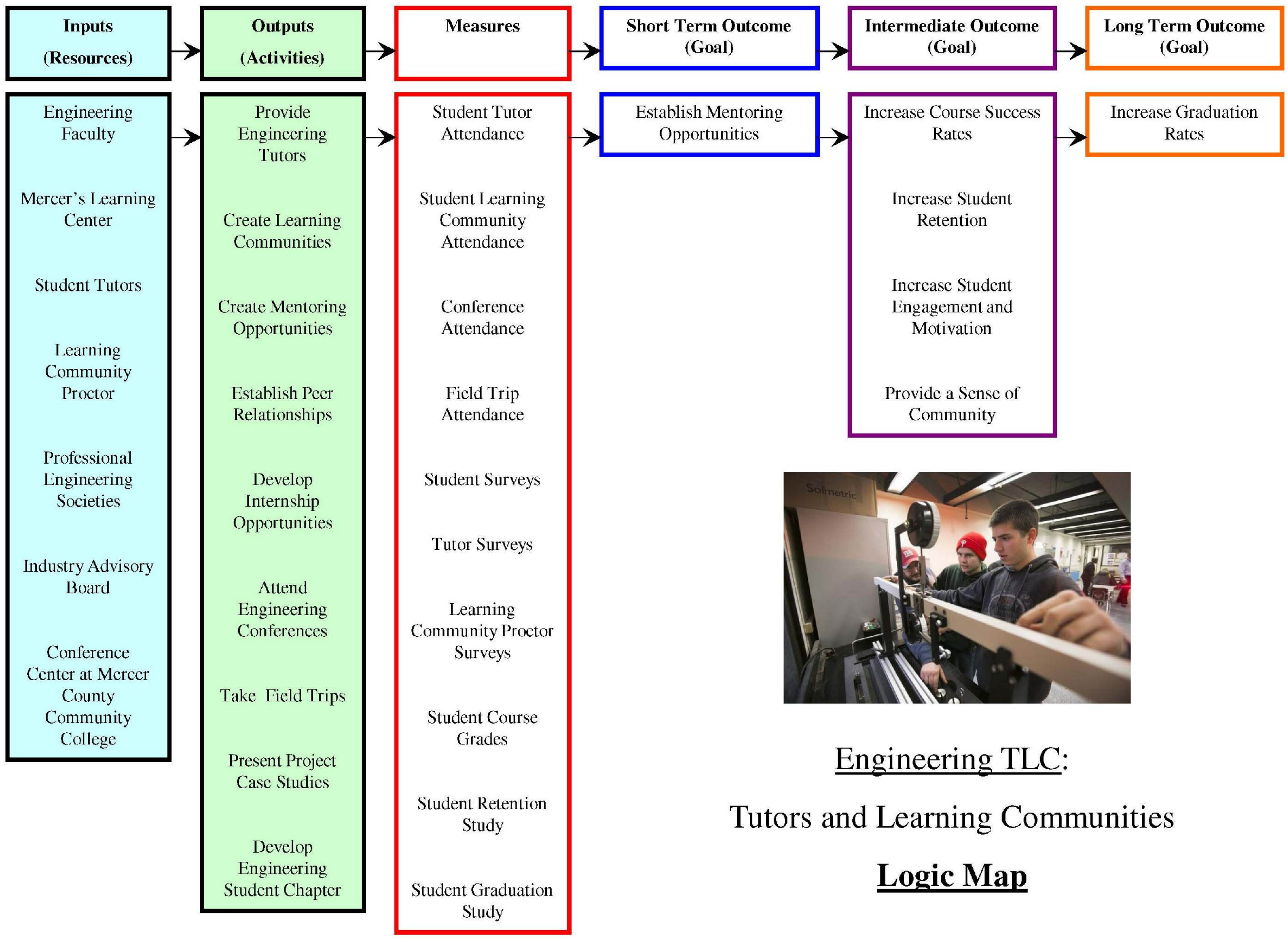
APPENDIX A

ENGINEERING TLC LOGIC MAP

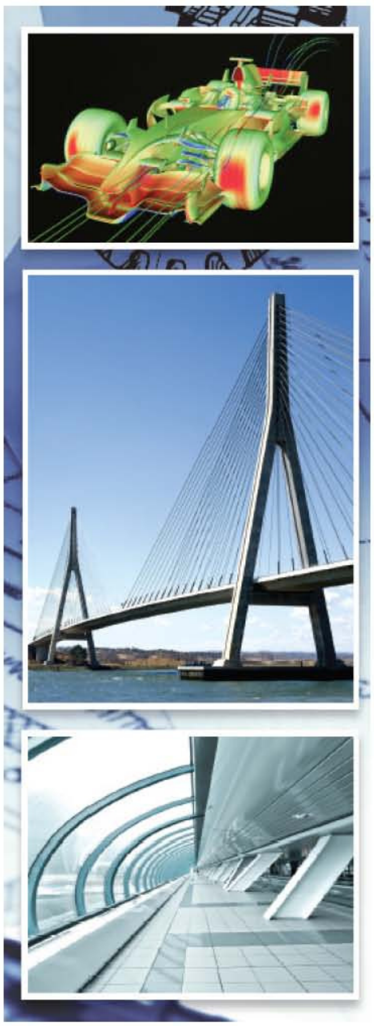


APPENDIX B

RECRUITMENT MATERIAL

To all Engineering Science AND Civil Engineering Technology majors:

We are pleased to announce that, for the first time, we will be offering a program for our engineering students that is similar to what many top 4-year schools offer. The program is entitled "Engineering TLC: Tutors and Learning Communities," which ***provides tutors, creates learning communities, and provides student mentoring opportunities***.



What is the Engineering TLC program?
The program is similar to what many top engineering schools currently offer. Schools such as Rutgers University, Drexel University and Virginia Tech currently use this program to provide and introduction to engineering, strengthen engineering teamwork opportunities, improve career preparation, and provide internship opportunities.

Once a week we will meet in a room that is equipped with computers and printers to allow you to work on your school assignments. Tutors will be available to help you. You'll be able to participate in weekly study groups, which will be facilitated by a proctor. You'll be able to work as a team to establish engineering partnerships with fellow students.

What are the benefits of the Engineering TLC program?
Students in the program will be able to:

- Develop engineering resumes
- Participate in industry internship opportunities
- Attend engineering conferences and meetings
- Enjoy access to engineering proctors, mentors, and tutors
- Attend engineering field trips
- View engineering project presentations by guest speakers
- Participate in a student chapter of an engineering society
- Participate in weekly learning communities and study sessions
- Enjoy free pizza at each weekly session

How much does the Engineering TLC program cost?
Participation in the Engineering TLC program is **FREE**. We only ask that you complete periodic online surveys.

How do I enroll in the Engineering TLC program and WHEN do we meet?
Just show up at our weekly meetings (Wednesdays from noon to 1pm in Room XXXX).

I look forward to seeing you each Wednesday at noon! Please feel free to contact me if you have any questions.

Professor Maccariella
XXXX@XXXX.edu

APPENDIX C

THEORETICAL BLUEPRINT FOR SURVEYS

	Access to engineering mentors	Confidence	Access to study groups	Engagement and motivation	Peer relationships
Student perception of Engineering TLC	How satisfied are you with access to engineering mentors?	How confident are you that you will succeed in the engineering program?	How satisfied are you with access to engineering study groups?	How engaged and motivated are you in the engineering program?	How satisfied are you with your current engineering student relationships?

APPENDIX D

SURVEY

Instructions

Please answer questions as they relate to you. Check the box that is most applicable to you or fill in the blanks.

1. How satisfied are you with access to engineering mentors?

Very Unsatisfied	Unsatisfied	Neither	Satisfied	Very Satisfied
○	○	○	○	○

2. How confident are you that you will succeed in the engineering program?

Very Unconfident	Unconfident	Neither	Confident	Very Confident
○	○	○	○	○

3. How satisfied are you with access to engineering study groups?

Very Unsatisfied	Unsatisfied	Neither	Satisfied	Very Satisfied
○	○	○	○	○

4. How engaged and motivated are you in the engineering program?

Very Disengaged	Disengaged	Neither	Engaged	Very Engaged
○	○	○	○	○

5. How satisfied are you with your current engineering student relationships?

Very Unsatisfied	Unsatisfied	Neither	Satisfied	Very Satisfied
○	○	○	○	○

6. Please tell us your Age and Gender

Age (years) __________

Gender (Female, Male, Other) __________

7. Your Ethnicity

- ○ Asian
- ○ African American
- ○ American Indian
- ○ Hispanic
- ○ White
- ○ Other

8. Please tell us your Enrollment and Grant status.

Full-time OR Part-time student

Are you currently receiving Federal Pell Grant funts?

9. Please tell us the high school you attended and reason for participating in the Engineering TLC program

What high school did you attend?

Why did you choose to join Engineering TLC?

10. Please tell us how we can improve Engineering TLC to better meet your needs.

APPENDIX E

THEORETICAL BLUEPRINT FOR INTERVIEWS

	Access to engineering mentors	Confidence	Access to study groups	Engagement and motivation	Peer relationships
Student perception of Engineering TLC	How did Engineering TLC affect your access to engineering mentors?	How did Engineering TLC affect your confidence regarding course and program success?	How did Engineering TLC affect your access to study groups?	How did Engineering TLC affect your engagement and motivation?	How did Engineering TLC affect your student relationships?
				How did the field trips affect your engagement and motivation?	How did the student chapter of the engineering society affect your student relationships?

APPENDIX F

OPENING SCRIPT FOR INTERVIEW

Hello, how are you today? I am a student at Old Dominion University, and I am conducting interviews for my dissertation. I am studying the impact of the Engineering TLC program that was offered this year.

This interview was designed to be approximately a half hour in length. However, please feel free to expand on the topic or talk about related ideas. Also, if there are any questions you would rather not answer or that you do not feel comfortable answering, please say so and we will stop the interview or move on to the next question, whichever you prefer.

I'd like to make sure you understand that your participation in this interview is voluntary. If you don't mind, I'd like to use an audio recorder to assist with my data collection. Is that okay with you? Please be aware that information gathered in this study is confidential, and we can use a pseudonym to protect your personal identity if you'd like. Would you like to use a pseudonym? (if yes) Would you like to select a pseudonym or would you rather I assign one for you?

You have the right to review and comment on information prior to the dissertation's submission. I'd like to thank you for your willingness to participate. Do you have any questions for me?

APPENDIX G

INFORMED CONSENT

Consent Form

I am aware that my participation in this interview is voluntary. I understand the intent and purpose of this research. If, for any reason, at any time, I wish to stop the interview, I may do so without having to give an explanation.

The researcher has reviewed the individual and social benefits and risks of this project with me. I am aware the data will be used in a dissertation that will be publicly available at the Old Dominion University Darden College of Education Campus. I have the right to review, comment on, and/or withdraw information prior to the dissertation's submission. The data gathered in this study are confidential with respect to my personal identity unless I specify otherwise.

If I have any questions about this study, I am free to contact the student researcher (James Maccariella, jmacc007@odu.edu, 609-560-1845) or the faculty adviser (Dr. Shana Pribesh, sbribesh@odu.edu, 757-708-0306). If I have any questions about my rights as a research participant, I am free to contact the chair of Darden College of Education's Human Subjects Review Committee: Dr. Ed Gomez, egomez@odu.edu, 757-683-6309.

I have been offered a copy of this consent form that I may keep for my own reference.

I have read the above form and, with the understanding that I can withdraw at any time and for whatever reason, I consent to participate in today's interview.

_________________________ _____________________

Participant's signature Date

____

Interviewer's signature

APPENDIX H

CLOSING SCRIPT FOR INTERVIEW

Again, I'd like to thank you for your participation in this study. All information will be kept confidential. I will keep the data in a secure place. Only myself and the faculty supervisor will have access to this information. Please feel free to contact me (Jim Maccariella, jmacc007@odu.edu, 609-560-1845) or my adviser (Dr. Shana Pribesh, sbribesh@odu.edu, 757-708-0306) if you have any questions or concerns. Upon completion of this project, all data will be destroyed or stored in a secure location. Is there anything additional that you'd like to share with me?

APPENDIX I

INTERVIEW PROTOCOL

1. Please describe how the Engineering TLC program affected your access to engineering mentors.
2. Please describe how the Engineering TLC program affected your access to study groups.
3. Please describe how the Engineering TLC program affected your engagement and motivation.
4. Please describe how the field trips affected your engagement and motivation.
5. Please describe how the Engineering TLC program affected your student relationships.
6. Please describe how the student chapter of the engineering society affected your student relationships.
7. Please describe how the Engineering TLC program affected your confidence regarding course and program success.
8. Is there anything that I should have asked you and didn't?

APPENDIX J

HUMAN SUBJECTS REVIEW

OLD DOMINION UNIVERSITY
DARDEN COLLEGE OF EDUCATION
IDEA FUSION

DARDEN COLLEGE OF EDUCATION
Human Subject Committee
Norfolk, Virginia 23529-0156
Phone: (757) 683-6695
Fax: (757) 683-5756

July 22, 2014 Approved Application Number: 201403026

Dr. Shana Pribesh
Department of Educational Foundations and Leadership

Dear Dr. Pribesh:

Your Application for Exempt Research with James Maccariella entitled "Engineering TLC (Tutors and Learning Communities) [Part A: Survey]" has been found to be EXEMPT under Category 6.2 from IRB review by the Human Subjects Review Committee of the Darden College of Education with the following condition: change the end date for the data collection to reflect a date after the start date of data collection.

The determination that this study is EXEMPT from IRB review is for an indefinite period of time provided no significant changes are made to your study. If any significant changes occur, notify me or the chair of this committee at that time and provide complete information regarding such changes. In the future, if this research project is funded externally, you must submit an application to the University IRB for approval to continue the study.

Best wishes in completing your study.

Sincerely,

Robert J. Spina, Ph.D., FACSM
Associate Dean for Undergraduate Education and College Assessment
Darden College of Education
Old Dominion University
rspina@odu.edu

Interim Chair
Darden College of Education Human Subjects Review Committee
Old Dominion University

OLD DOMINION UNIVERSITY
DARDEN COLLEGE OF EDUCATION
IDEA FUSION

DARDEN COLLEGE OF EDUCATION
Human Subject Committee
Norfolk, Virginia 23529-0156
Phone: (757) 683-6695
Fax: (757) 683-5756

July 22, 2014 Approved Application Number: 201403027

Dr. Shana Pribesh
Department of Educational Foundations and Leadership

Dear Dr. Pribesh:

Your Application for Exempt Research with James Maccariella entitled "Engineering TLC (Tutors and Learning Communities) [Part B: Interviews]" has been found to be EXEMPT under Category 6.2 from IRB review by the Human Subjects Review Committee of the Darden College of Education.

The determination that this study is EXEMPT from IRB review is for an indefinite period of time provided no significant changes are made to your study. If any significant changes occur, notify me or the chair of this committee at that time and provide complete information regarding such changes. In the future, if this research project is funded externally, you must submit an application to the University IRB for approval to continue the study.

Best wishes in completing your study.

Sincerely,

Robert J. Spina, Ph.D., FACSM
Associate Dean for Undergraduate Education and College Assessment
Darden College of Education
Old Dominion University
rspina@odu.edu

Interim Chair
Darden College of Education Human Subjects Review Committee
Old Dominion University

OFFICE OF THE VICE PRESIDENT FOR RESEARCH

Physical Address
4111 Monarch Way, Suite 203
Norfolk, Virginia 23508
Mailing Address
Office of Research
1 Old Dominion University
North, Virginia 23529
Phone(757) 683-3460
Fax(757) 683-5902

DATE:	November 9, 2014
TO:	Shana Pribesh
FROM:	Old Dominion University Education Human Subjects Review Committee
PROJECT TITLE:	[678036-1] Engineering TLC Part C
REFERENCE #:	
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	
REVIEW CATEGORY:	Exemption category # *6.4*

Thank you for your submission of New Project materials for this project. The Old Dominion University Education Human Subjects Review Committee has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will retain a copy of this correspondence within our records.

If you have any questions, please contact Ed Gomez at 757-683-6309 or egomez@odu.edu. Please include your project title and reference number in all correspondence with this committee.

This letter has been electronically signed in accordance with all applicable regulations, and a copy is retained within Old Dominion University Education Human Subjects Review Committee's records.

APPENDIX K

HUMAN SUBJECTS TRAINING

COLLABORATIVE INSTITUTIONAL TRAINING INITIATIVE (CITI)

SOCIAL & BEHAVIORAL RESEARCH - BASIC/REFRESHER CURRICULUM COMPLETION REPORT

Printed on 11/04/2014

LEARNER	James Maccariella (ID: 3543239)
DEPARTMENT	Community College Leadership
EMAIL	jmacc007@odu.edu
INSTITUTION	Old Dominion University
EXPIRATION DATE	11/04/2015

SOCIAL & BEHAVIORAL RESEARCH - BASIC/REFRESHER : Choose this group to satisfy CITI training requirements for Investigators and staff involved primarily in Social/Behavioral Research with human subjects.

COURSE/STAGE:	Basic Course/1
PASSED ON:	11/04/2014
REFERENCE ID:	14497463

REQUIRED MODULES	DATE COMPLETED	SCORE
Belmont Report and CITI Course Introduction	11/04/14	3/3 (100%)
Students in Research	11/04/14	9/10 (90%)
History and Ethical Principles - SBE	11/04/14	5/5 (100%)
Defining Research with Human Subjects - SBE	11/04/14	4/5 (80%)
The Federal Regulations - SBE	11/04/14	5/5 (100%)
Assessing Risk - SBE	11/04/14	4/5 (80%)
Informed Consent - SBE	11/04/14	5/5 (100%)
Privacy and Confidentiality - SBE	11/04/14	5/5 (100%)
Research with Prisoners - SBE	11/04/14	5/5 (100%)
Research with Children - SBE	11/04/14	5/5 (100%)
Research in Public Elementary and Secondary Schools - SBE	11/04/14	5/5 (100%)
International Research - SBE	11/04/14	5/5 (100%)
Internet-Based Research - SBE	11/04/14	5/5 (100%)
Research and HIPAA Privacy Protections	11/04/14	5/5 (100%)
Conflicts of Interest in Research Involving Human Subjects	11/04/14	4/5 (80%)

For this Completion Report to be valid, the learner listed above must be affiliated with a CITI Program participating institution or be a paid Independent Learner. Falsified information and unauthorized use of the CITI Program course site is unethical, and may be considered research misconduct by your institution.

Paul Braunschweiger Ph.D.
Professor, University of Miami
Director Office of Research Education
CITI Program Course Coordinator

VITA
JAMES E. MACCARIELLA, JR., P.E.

maccarij@mccc.edu

EDUCATION

Ph.D. Community College Leadership, Old Dominion University, 2015
M.S. Civil Engineering, Drexel University, 1996
B.S. Civil Engineering, Drexel University, 1992
B.S. Architectural Engineering, Drexel University, 1992

TEACHING EXPERIENCE

MERCER COUNTY COMMUNITY COLLEGE
West Windsor, NJ, August 2009 to Present:
Associate Professor and Coordinator of the Engineering Science and Civil Engineering Technology programs. Responsible for instruction, program development and assessment, curriculum development, coordination of adjunct faculty, high school outreach, workforce development, preparation of grants and proposals, and student advisement.

PRESENTATIONS and PAPERS

Maccariella, J.E., (2015). *Engaging Community College Students Using an Engineering Learning Community*. Engaging Learners in the 21st Century, West Windsor, NJ, August 25, 2015.

Maccariella, J.E. (2014). *Assessment of Research Methods used to Identify Indicators for Engineering Student Success*, American Educational Research Association 2015 Annual Meeting, Chicago, IL, April 16-20, 2015; Virginia Educational Research Association 2014 Conference, Charlottesville, VA, September 18-19, 2014; Southeastern Association for Community College Research 2014 Conference, Huntsville, AL, September 14-16, 2014.

Maccariella, J.E., (2013). *Motivating Students to Succeed Using Innovative Concepts from Industry*. Engaging Learners in the 21st Century, West Windsor, NJ, August 21, 2013.

Maccariella, J.E., (2012). *Engaging Engineering Students by Collaborating with Business and Industry.* STEMtech Conference, Kansas City, MO, October 30, 2012.

Maccariella, J.E., (2011). *Motivating Engineering Students Using Innovative Concepts from Industry*, STEMtech Conference, Indianapolis, IN, October 4, 2011.

Maccariella, J.E., (2007). *The Role of Adjuncts In Teaching ASCE's Body of Knowledge*, American Society for Engineering Education, 2007 Annual Conference and Exposition, Honolulu, Hawaii, June 24-27, 2007.

AWARDS:

Principal Investigator for Scholarships in Science, Technology, Engineering, and Mathematics (S-STEM): *Scholarships for Advancing Mercer STEM Students (SAMS)*. Sponsored by the National Science Foundation, 2015-2020. Funding amount: $600,000.

Outstanding paper award for *Assessment of Research Methods used to Identify Indicators for Engineering Student Success*. Southeastern Association for Community College Research. September 2014.

Principal Investigator for a Student Learning Improvement Grant: *Engineering TLC- Tutors and Learning Communities*. Sponsored by Mercer County Community College, Fall 2014-Spring 2015. Funding amount: $8,800.

Darden College of Education Graduate Fellowship, Summer 2014, Old Dominion University