Modeling First -Year Engineering Retention Rate and Success in STEM at Youngstown State University

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ABSTRACT

Tracking retention rate is an important factor given the complexity of establishing the factors leading to an increase or decrease in graduation rates, especially in engineering programs that on a national level cannot meet the demand. It enables the institution to assess the periodic progression of students in its programs. As such, it can be used as an indication of: suitability of teaching methodologies, student expiates, curricular support structures, or the environment in a program or academic unit. Although by itself retention cannot answer definitively answer causality questions, educators can begin to determine where issues may be present to gather further data that can help understand the experiences of students. This study considers the graduation and retention rates from the engineering programs at Youngstown State University (Chemical, Civil, Electrical, Industrial, and Mechanical) for the past 8 years (2005-2013). From the perspective of who goes into engineering and who is retained. The approach is to track students starting in the First- Year Engineering Program and determines where each of the students is today (enrolled or graduated from YSU outside of engineering, enrolled or graduated from YSU within engineering, or no longer at university. The direct assessment will come in the form of tracking retention (frequency counts, proportions, and simple statistical tests – gender, race / ethnicity, high school preparation). Once we determine student pathways (graduation, succession, and exit rates) we can establish a continuous procedure to track retention on an on-going basis and propose recommendations for improvements in the engineering program (based on the type(s) of students who do not persist in engineering).

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DEDICATION

To my mother for her love and support always

Ahlam Ibrahim

TABLE OF CONTENTS

List of tables……………..………………………………………………………………………… vii

List of figures………………..…. ……………………………………………………………………viii

1.0 Introduction……………….. ………………………………………………………………… 1

1.1 First Year Engineering Achievements 3

1.2 Youngstown State University.. 6

1.3 Research Questions 8

1.4 Thesis Outline. 9

2.0 Literature Review and Development of a model for engineering student success 10

2.1 Improtance of model based on empirical studies 11

2.2 Review of previous engineering retention models…………………………………...12

2.3 Application of Tinto's mode of attrition and educational theories 17

2.4 Development of a retention model for first year engineering Students……………...21

3.0 Methodology…………….. 37

3.1 Ethnicity and Gender Differences 37

3.2 Research Design and Target Studies 38

3.3 Data Collection and Analysis 39

4.0 Data Analysis……………….. 40

4.1 Analysis on Engineering population... 40

4.2 Majority Data Analysis.. 44

4.3 Analysis of Minority Data 54

4.4 Regression Analysis.. 57

5.0 Conclusion and Recommendations 63

5.1 Conclusion……. 63

5.2 Recommendations.. 66

5.3 Tracking Changes 67

Bibliography……………... 68

LIST OF TABLES

TABLE 1 EXAMPLES OF STUDENT SUCCESS THEORIES 18

TABLE 2. COUNT OF ALL STUDENTS ENROLLED IN ENGR 1550 (ENGINEERING CONCEPTS) 2005-2012 40

TABLE 3. PERCENTAGE OF ALL STUDENTS ENROLLED IN ENGR 1550 (ENGINEERING CONCEPTS) BY YEAR 2005-2012 40

TABLE 4. T-TEST RESULTS FOR GENDER SUCCESS IN ENGINEERING 41

TABLE 5. NUMBER OF MALE AND FEMALE STUDENTS BY RACIAL GROUP ENROLLED IN ENGR 1550 (ENGINEERING CONCEPTS) 2005-2012 42

TABLE 6. PERCENTAGE OF MINORITY AND MAJORITY STUDENTS ENROLLED IN ENGR 1550 BY YEAR 43

TABLE 7. T-TEST RESULTS FOR GRADUATION TIME BY ENGINEERING DISCIPLINE 54

TABLE 8. REGRESSION RESULTS FOR MODELING MECHANICAL ENGINEERING SUCCESS 58

TABLE 9. REGRESSION RESULTS FOR MODELING ELECTRICAL ENGINEERING SUCCESS 59

TABLE 10. REGRESSION RESULTS FOR MODELING CIVIL ENGINEERING SUCCESS 60

TABLE 11. REGRESSION RESULTS FOR MODELING CHEMICAL ENGINEERING SUCCESS 60

TABLE 12. REGRESSION RESULTS FOR MODELING INDUSTRIAL ENGINEERING SUCCESS 61

TABLE 13. REGRESSION RESULTS FOR MODELING GRADATION TIME 62

LIST OF FIGURES

FIGURE 1. THE HIGHER THE RETENTION RATE, THE HIGHER THE GRADUATION RATE (EDUCATION TRUST, 2011).... 3

FIGURE 2. STUDENT SUCCESS MODEL (VEENSTRA, 2008) 10

FIGURE 3. THE PIPELINE THEORY (VEENSTRA, 2008) 13

FIGURE 4. TRANSMISSION LINE MODEL (WATSON AND FROYD, 2007) 16

FIGURE 5. ILLUSTRATING A BLOCK DIAGRAM FOR FIRST-YEAR STUDENT ENGINEERING SUCCESS (VEENSTRA, 2008) 21

FIGURE 6. PROCESS OF DEVELOPING IN THE FIRST-YEAR ENGINEERING STUDENT SUCCESS MODEL (VEENSTRA, 2008) 22

FIGURE 7. ILLUSTRATING LOSS WITH REGARD TO RETENTION OR ATTRITION AMONG ENGINEERING STUDENTS (VEENSTRA, 2008) 35

FIGURE 8. ILLUSTRATION OF THE FIRST-YEAR ENGINEERING STUDENTS' SUCCESS MODEL 36

FIGURE 9. NUMBER OF STUDENTS BY GENDER WHO STARTED IN ENGR 1550 BY YEAR 42

FIGURE 10. PERCENTAGE OF MAJORITY AND MINORITY STUDENTS STARTING IN ENGR 1550 BY YEAR 43

FIGURE 11. PERCENTAGE OF GRADUATED STUDENT'S DISCIPLINE BETWEEN 2005-2013 SINCE STARTING IN ENGR 1550 44

FIGURE 12. PERCENTAGE OF GRADUATED MAJORITY STUDENT'S DISCIPLINE SINCE STARTING IN ENGR 1550 44

FIGURE 13. PERCENTAGE OF CONTINUING MAJORITY STUDENT'S DISCIPLINE SINCE STARTING IN ENGR 1550 45

FIGURE 14. SUMMARY OF ENGINEERING STUDENT GRADUATES BY DISCIPLINE 45

FIGURE 15. SUMMARY OF CONTINUING STUDENT'S ENGINEERING DEGREE BY DISCIPLINE (2005-2012) 46

FIGURE 16. ENROLLMENT OF CONTINUING ENGINEERING STUDENT'S MAJORS BY GENDER 47

FIGURE 17. NUMBER OF GRADUATE'S DISCIPLINE BY GENDER WHO STARTED IN ENGR 1550 SINCE 2005 47

FIGURE 18. NUMBER OF CONTINUING MAJORITY STUDENTS TOWARDS A DEGREE BY MAJOR 48

FIGURE 19. NUMBER OF YEARS IT TOOK ENGINEERING STUDENTS TO GRADUATE FROM YSU SINCE 2005 48

FIGURE 20. A AND B SUMMARY OF MAJORITY AND MINORITY STUDENTS MAJORS WHO GRADUATED IN 4 YEARS (SINCE STARTING IN ENGR 1550 IN 2005) 49

FIGURE 21. A AND B SUMMARY OF MAJORITY AND MINORITY STUDENTS WHO GRADUATED IN 5 YEARS (SINCE STARTING IN ENGR 1550 IN 2005) 50

FIGURE 22. A AND B SUMMARY OF MAJORITY AND MINORITY STUDENTS MAJORS WHO GRADUATED IN 6 YEARS (SINCE STARTING IN ENGR 1550 IN 2005) 51

FIGURE 23. A-C ENROLLMENT OF GRADUATE STUDENT'S ENGINEERING DISCIPLINE WHO GRADUATED IN 4,5 AND 6 YEARS BY GENDER 52

FIGURE 24. A-C SUMMARY OF STUDENT'S ENGINEERING DISCIPLINE WHO GRADUATED IN 4,5 AND 6 YEAR 53

FIGURE 25. PERCENTAGE OF MINORITY STUDENTS RACE WHO STARTED IN ENGR 1550 SINCE 2005-2012 54

FIGURE 26. PERCENTAGE OF MINORITY STUDENTS WHO GRADUATED, CONTINUED, AND NO LONGER AT YSU SINCE STARTING IN ENGR 1500 IN 2005 55

FIGURE 27. COUNT OF ENGINEERING MINORITY STUDENT MAJORS BY GENDER SINCE STARTING IN ENGR 1550 (2005-2012) 55

FIGURE 28. PERCENTAGE OF CONTINUING ENGINEERING MINORITY STUDENTS BY DISCIPLINE (2005-2012) 56

FIGURE 29. NUMBER OF YEARS IT TOOK MINORITY STUDENTS TO GRADUATE SINCE STARTING ENGR 1550 IN 2005 57

1.0 INTRODUCTION

Engineers serve a critical role in the economy and global competitiveness. Nevertheless, the profession is experiencing challenges in the U.S. as fewer engineers enter the workforce and are needed to meet the workforce demand (NAE, 2004; NAS, 2005). This shows a promising opportunity for young professionals entering the workforce. Statistics from the U.S Bureau of Labor Statistics indicates a projected growth of 43% in the engineering and computer fields between 2004 and 2014, which translates to a 4% yearly increase in terms of job availability for engineers (U.S Department of Education, 2006; Hacker, 2005). Professionals who have reached retirement age worsen this deficit of the gradual exit from the engineering sector. Even though there was constant enrollment for engineering bachelor's degree programs from the mid 1980s to 2003, there is no evidence to indicate the deficit has been reduced (National Science Board, 2006).

Another emerging issue is the impact that the shortage of engineering professionals will have on the high level of innovation associated with the United States of America. Indeed, the decline in enrollment of engineering students in Bachelor's degree programs has a direct impact on the associated research activities that provide the pipeline for innovation (NAS, 2005). Gradually, the U.S has fallen behind other nations when it comes to producing leading scientists and engineers. To illustrate this, 60% of bachelor degree program students graduating in China are primarily from engineering and science based courses while in the U.S only is at 30% from 5% of this group are engineering graduates (Friedman, 2006; NSB, 2006). Consequently, this effects competition in terms of innovation and global competitiveness.

Despite the fact that women make up 56% of the entire U.S population, when it comes to their representation in the engineering graduates they only make up 20% (Grose, 2006). Many changes have taken place since 2001 when only 13% of the minorities earned bachelor degrees program in engineering. This implies that more attention needs to be given to minorities and women in terms of their recruitment into engineering bachelor degree program. This should be able to bridge the gap created by the shortage of professionals in the engineering sector. According to the National Science Board (2007), the Federal government needs to come up with new ways of increasing interest in engineering and science-based programs.

These problems point to two major emerging issues that are silently affecting the engineer bachelor programs: (1) student recruitment and (2) retention. These need to be taken, as a serious matters among teaching and engineering faculty members. According to Dew (2007), there is need for the higher education sector to improve the teaching methods and quality aspects that will lead to improvement in management. Among these quality aspects is the level of student success and completion rates in critical courses. The fact that available data shows an increasing shortage of engineers, having higher retention rates is a suitable factor. According to Clough (2006), the graduation rate of students enrolling in engineering programs in the US is 55%. This means that close to a half of those who enroll either decide to change to other programs or drop out. In this regard, improving this rate will lead to a significant increase in the number of engineers successfully joining the professional world and addressing the shortage. One of the most important areas of improvement is the first-year engineering student retention rate. This refers to the number of engineering students that proceed with their respective engineering programs past their first-year (Tinto 1993), in addition to first-year tends to have the lowest retention rates compared to other college years.

1.1 FIRST YEAR ENGINEERING ACHIEVEMENTS

An important step in addressing engineering student retention is to evaluate who does not continue in engineering after their first-year and why. This is critical to understanding the existing undergraduate engineering graduation rates that are the "supply" for the previously mentioned national demand for qualified engineers. Modeling first-year engineering student retention rates will help to aid understanding of factors for success. This model is shown in figure shows that a higher first-year engineering student retention rate leads to a higher graduation rate. Based on the relationship between the six-year graduation rate and the first-year retention rate for similar universities to Youngstown State.

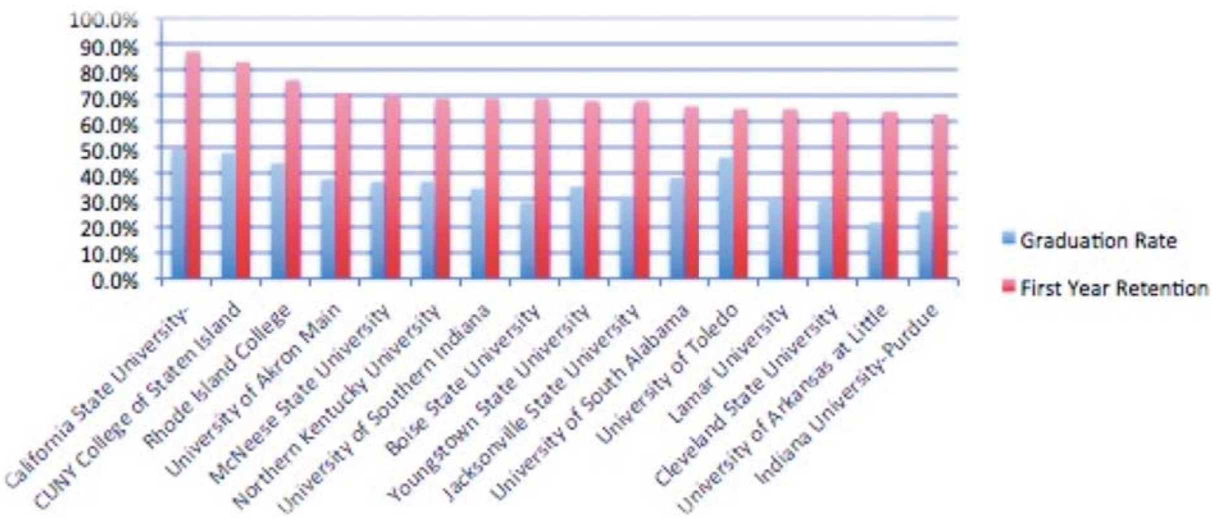


Figure 1. The Higher the Retention Rate, the Higher the Graduation Rate (Education Trust, 2011)

Prior studies of first-year engineering student retention rates have looked at both single and multiple institutions. For example, prior studies focused on multiple institutions indicated that the level of high school preparation, science preparation, math preparation, intensity of school curriculum, science based orientation, and display of an aspiration of taking up a career in engineering as significant predictors at national level (Astin & Astin, 1992; Adelman, 1998). More specifically, the Astin and Astin study assessed pre-college factors that affect retention such as mixed expectations of college experience and attitudes at high school level towards engineering. The study showed that first-year engineering students begin having a poor attitude towards technical courses such as engineering and they also think that it will make their college experience more challenging.

Indeed, given the level of standardization provided through admission of similar SAT/ACT or other standardized tests or surveys across different institutional settings provide a higher possibility of getting a better prediction trends to understand the subject. On the other hand, focusing on multiple institutional settings has its own disadvantages. Among the disadvantages include the complexity in modeling the interaction between different variables and decreased efficiency in the implementation of intervention measures.

Focusing on a single institution makes it simplified to model the interaction among different variables in the study. It also makes it easier in identifying challenges that emerge when implementing an intervention; hence, easier to understand issues regarding student retention. The institution is responsible for promoting a suitable climate that molds the student academically and socially through provision of educational material, curriculum implementation, and educational advice. Indeed, by focusing on a single institution, it enables the researcher to look at interaction between variables in detail. According to Braxton (2000) and Dey (2007), there is need for more single institution focus studies to better understand student retention issues. Additionally, a single institution study enables the researcher to look into issues regarding high school preparation levels.

1.2 YOUNGSTOWN STATE UNIVERSITY

Youngstown State University is an urban, public, research university in Northeast Ohio with a wide variety of higher education programs and majors serving ~13,000 undergraduate students, 86% of which come from within the state of Ohio. It is a very accessible school for students of diverse academic preparations and socioeconomic status. Specifically, it guarantees admission to any student earning a high-school degree or GED equivalent (although some programs, including engineering, do have restricted admissions). The STEM College is 72% male and 28% female and 15% minority student population. Most students in the STEM College are of traditional college age (80% less than 25 years old), are full time students (85%), and live off campus and commute (90% commute). The STEM College had a total enrollment in the fall of 2012 of 2,833 students, including 184 graduate and doctoral students, and 36 non-resident aliens.

The First-Year Engineering Program had ~215 incoming students in the fall of 2012. Of those students, 84% were male, 16% female. In terms of race / ethnicity 86% were white, 14% underrepresented minorities. It is a general program such that all intended engineering disciplines take the same courses including:

(1) ENGR 1500 – Engineering Orientation – 1 Credit (fall)

(2) ENGR 1550 – Engineering Concepts – 2 Credits (fall)

(3) ENGR 1560 – Engineering Computing – 3 Credits (spring)

But beyond the First-Year Engineering Course sequence (and the fundamental mathematics, chemistry, and physics courses) students move to one of five ABET accredited engineering programs: Civil, Chemical, Electrical, Industrial, or Mechanical Engineering. There is no application process, rather as long as students have met the requirements of getting a C or better in Calculus, Chemistry, and Composition (the 3 C's) as well as the First-Year Engineering courses then they are transitioned over. Typically students graduate in 4-6 years, although there are certainly exceptions. This study was focused on better understanding retention and graduation rates, and specifically who is persisting and who is not.

1.3 RESEARCH QUESTIONS

The research questions are as follows:

1. Is race/ethnicity a statistically significant factor in engineering persistence from year to year and retention to graduation in engineering?
2. Is gender a statistically significant factor in engineering persistence from year to year and retention to graduation in engineering?
3. What are the graduation rates of (4,5,and 6 year) by Engineering program and are differences statistically significant?
4. What are the retention rates by Engineering program and are differences statistically significant?
5. Can an adequate model be developed that can predict academic performance and retention among first-year engineering students to graduation at YSU?

1.4 THESIS OUTLINE

The research questions focus on the differences between engineering students' retention in the first-year, general college academic outcomes, and retention levels at STEM. Providing the answer to these questions in the aim to develop a new model for first-year college engineering retention. The literature review provided in chapter II is focused on the student success model during the first-year of engineering. Chapter III is focused on how to analyze the collected data. Finally, chapter IV presents the results from the data analysis while chapter V is focused on recommendations and conclusions.

2.0 LITERATURE REVIEW AND DEVELOPMENT OF A MODEL FOR ENGINEERING STUDENT SUCCESS

This chapter aims at developing a new model based on related prior studies. The attributes of student success included student retention levels and academic performance indicated by GPA (Levin and Wyckoff, 1988; Lackey et al, 2003; French et al, 2005). On the other hand, student retention was defined from the perspective of the number of students who proceed with their studies onto the second year. At the institutional level, student retention is defined as students continued attendance at both college and university. The current study will use the following model shown in Figure 2 to predict retention levels and academic success.

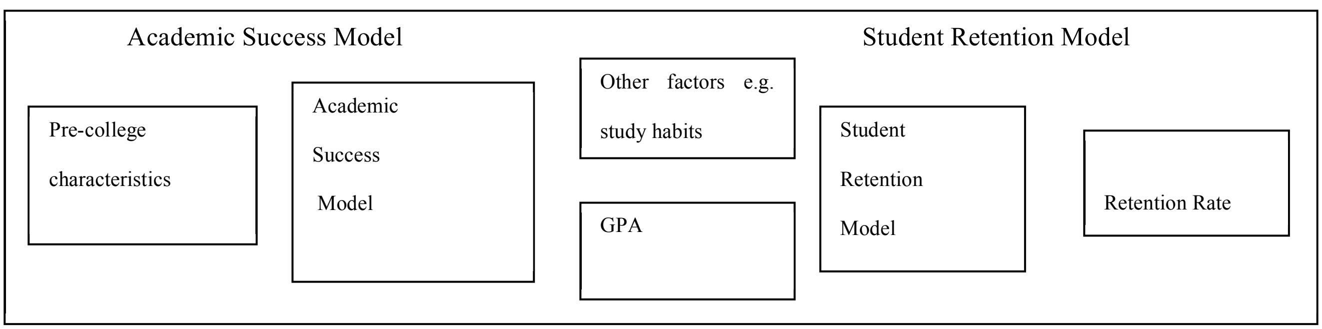


Figure 2. Student Success Model (Veenstra, 2008)

When students are attending high school they go through different social and academic experiences. During the transition period from high school to college, there are many changes that student experience (Morrison, 2007). Students tend to carry forward their high school experiences into the college setting. This guides the assumption that a student's pre-college characteristics play a major role in determining their individual contributions towards ensuring academic success during the first year. They also influence the decision that the student will make as to whether to return to engineering school in the second year. In essence, the current study addresses the notion that retention at first year level is different from general student retention. This study is focused on the development of a model of student retention based on pre-college characteristics and first year performance. Figure 2 above illustrates the academic success model as determined by pre-college characteristics. The following aspects will be addressed:

- Importance of modeling based on empirical studies in section 2.1
- Review of previous engineering retention models in section 2.2
- Application of Tinto's model of attrition and educational theories in section 2.3
- Development of a retention model for first-year engineering at YSU in section 2.4

2.1 IMPORTANCE OF MODELING BASED ON EMPIRICAL STUDIES

It is important to understand the development of a model before formulating a predication for student success. In the current study, preference will be given to 'model'. Previously, the word 'theory' has been used to refer to a set of interconnected concepts (Tribus, n.d). Theories have been widely used to give meaning to experiences (Deming, 1994). In Deming's approach, theory was used as a basis of developing new knowledge. In Deming's perspective, theory was used to understand the processes behind a new experience. On the contrary, Peter Senge emphasized the essence of using mental models as a way of improving understanding about something (Dean, 2004). In this regard, a model provides a basis through which it is possible to subject empirical studies to analysis, revise an existing model, and develop a new one. According to Box, Hunter, and Hunter (1978), in scientific research, model development may employ a deductive or inductive thinking process. In this approach, the deductive thinking process is used to accomplish a comparison between a data set and the mode, while the inductive thinking process is used to modify the model when there are significant differences between the data set and the model. As such, a model may be similar to a hypothesis. Any empirical analysis focuses on validating the hypothesis. When the outcome of the empirical analysis is negative, it may be necessary to modify the model. This process emphasizes the validity of using a model. Additionally, when we look at the Shewhart Plan-Do-Check-Act cycle, the Plan stage is represented by a model, the Do stage is represented by an empirical study, the Check stage is represented by validation process for the empirical study, and the Act stage is represented by the changes made to the model (Veenstra, 2008, p.21). A good illustration of this process can be found in the Tinto model for retention in which he used results over a 30-year period to inform the changes in his model.

2.2 REVIEW OF PREVIOUS ENGINEERING RETENTION MODELS

As earlier noted, the model in this research suggests that the success level in engineering is different from the success level in the general college. In this regard, the following are existing models of retention and success focusing on engineering:

The Pipeline Theory

This model depicts a continuous occurrence of leaking attrition that begins from middle school up to the time the student graduates from engineering school. Figure 3 illustrates this perspective.

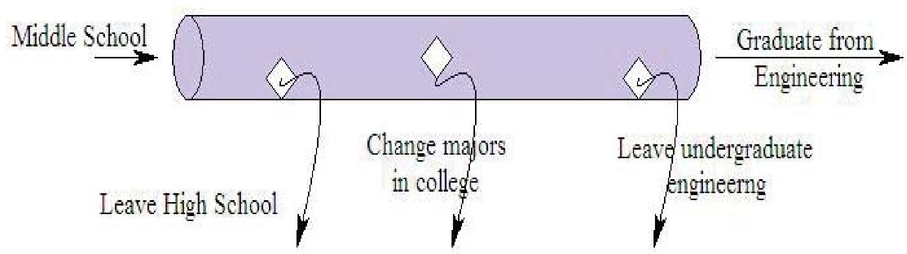


Figure 3. The Pipeline Theory (Veenstra, 2008)

Johnson and Sheppard (2002) used the pipeline theory to analyze the decision-making attributes of high school students before joining college, enrolling in an engineering college, and graduating. Their analysis also focused on important ethnicity and gender attributes. Out of the 1990 senior high school participants, only 87% successfully graduated from high school level, another 28% successfully enrolled to a 4-year college, while 2.3% successfully enrolled an engineering process, and 1.6 % successfully graduated from their respective engineering programs. From this perspective, the authors were able to identify lack of financial issues and high level of high school mathematics preparation as factors that lead to the occurrence of major differences in enrolment rates among minority students and others. In essence, the pipeline theory is useful in establishing how the loss of students occurs in the respective transition periods starting from high school through engineering college. Nevertheless, amore direct approach is needed to understand the reasons that make students to leave or proceed to an engineering field.

The Path Model

The path model was proposed by Adelman as a response to the pipeline model (Adelman, 1998). This model relies on the observation that math and science subjects taken at high school level closely resemble those taken by science, math, and engineering majors at college level. This implies that first-year students taking engineering courses may easily change science or math programs without losing a lot of time. According to the path model, this is the reason why STEM programs remain competitive. This competitive nature and ease with which first-year students can change to other programs play a role in influencing the choices that students make. In as much as the path model offers some explanation, it is still not effective in understanding the reasons that make students to change from engineering programs.

The Transmission Line Model

According to Watson and Froyd (2007), engineering student success model was essentially intended to increase the diversity in engineering schools. This was their response to the pipeline model, which they said was only effective in an engineering college where the student body has less diversity. Even though the leaks depicted in the pipeline theory may be interpreted as reasons for leaving, they cannot be isolated to specific reasons. The Transmission Line Model focused on underrepresented minorities and categorized them into three distinct areas as follows:

i. Stop leak (Community Building):

This stage represents building a community through formulation of the necessary networks within underrepresented groups to improve welfare.

ii. Stop leaks (Cognitive Ability Development):

This stage represents initiating development cognitive abilities in which the weaknesses existing within members of the underrepresented groups can be addressed using suitable intervention.

iii. Increase intake:

This stage represents occupational choice development in which members in the underrepresented groups are able to join engineering courses and careers.

In essence, community building is essential in developing self-identity in an individual while cognitive ability intervention improves their preparation for engineering courses and career. According to Watson and Froyd the pipeline used a simple approach that ignored the interactions that take place between self-identity, cognitive ability, and career identity. In their view, interventions rarely focus on creating a new system, but are mostly added onto an existing one. Thus, using the transmission line approach, Watson and Froyd found that they could depict the transfer of energy from between self-identity development, cognitive ability, and occupational choice development. This relationship is illustrated in Figure 4 where the curriculum is associated with cognitive ability development. In this approach, energy may be transferred from academics into identity development creating an imbalance. According to Watson and Froyd (2007), the transmission line approach minimizes the loss of energy between the three developmental elements. This implies that identity, cognitive, and career developments have to thrive simultaneously so that there is a seamless exchange of energy between them. For instance, looking at the career development process of an engineer should be a continuous loop that takes place prior to joining the first-year students, and throughout their undergraduate program.

Figure 4. Transmission Line Model (Watson and Froyd, 2007)

In this regard, the transmission model was influential in influencing some of the empirical hypotheses in the current study because of the focus it gives to identity, cognitive, and career development.

2.3 APPLICATION OF TINTO'S MODEL OF ATTRITION AND EDUCATIONAL THEORIES

The process of coming up with a model for first-year engineering students retention involves one of the following:

i. Formulate a model using a specific learning theory

ii. Revise a model that has already been proposed or used

In section 2.2, the items discussed failed to take into account the social and academic background as important factors that may influence retention outcomes. The current study will recommend suitable strategies that would be used to improve success in terms of retention. The development of a model is intended to provide a framework of the solution. In this regard, the availability of a model will benefit the current research through analysis of empirical studies focusing on those models. This prompted me to revise an existing model to provide a framework for my research.

General College Success Theories

There are numerous student success theories that have been developed focusing on success levels in the higher learning environment. Table 1 gives a preview of some of these theories. According to Braxton and Hirschy (2005), the theories focusing on the reasons behind students leaving college without earning a degree address four main factors: psychological factors, economic factors, sociological factors, and organizational theories.

Table 1 Examples of Student Success Theories

Researcher	Name of Theory	Main Points
Alexander Astin	Theory of involvement	▪ Empirically based on Higher Education Research Institute (HERI) longitudinal study ▪ Persistence related to student involvement ▪ Behavioral model
John Bean	Theory of student attrition	▪ Importance of interaction with faculty ▪ Working off-campus leads to attrition
Vincent Tinto	Interactionalist Theory of Student Departure	▪ Separation from home environment and integration into college environment ▪ Importance of integration into environment both academically and socially ▪ Persistence related to student involvement, including interaction with faculty and other students ▪ Based on experiences, student changes goals

Berger and Milem (1999)

From all these theories, Braxton and Hirschy (2005) noted that the Tinto Interactionalist Theory has been widely used in the studies focusing on why students decide to depart from their studies. In this regard, focusing on the aspects identified in Table 1 and the reputation of the Tinto model, an effort was made to revise its components into a working model that can be used as a framework for understanding success in first-year engineering courses.

Tinto's Model

This model was introduced in the 1970's during which it was subjected to several empirical studies and revised to illustrate the process of adjustment to college experience (Tinto, 1993; Tinto, 2006). According to the model, a student must abandon adjust to a new college culture. During this process of adjustment, the student brings with him unique pre-college characteristics, college goals, and career goals. Once the student is firmly settled, he undergoes another process of social and academic integration to enable them fit within the organizational structure. In Tinto's model, social integration refers to a student's exhibiting a healthy social relationship with their peers as well as staff. Academic integration refers to the student being able to meet the desired academic objectives. This leads to value added education where there is persistence in student performance. This can be illustrated using a student intending to join college with a specific set of career objectives. As the student gets academically and socially integrated, he may decide to change their goals to match that of their career.

The Tinto model essentially focused on the experience students have during their 4 years in college. This model focused more on social and academic experiences and less on precollege characteristics. This has led some critics to discuss whether these are the most important attributes in determining student success. In this regard, Braxton (2000) remarked that the Tinto model tends to focus more on social aspects of integration as opposed to the academic aspects. On the contrary, there are other researchers who have found that the Tinto model actually highlights more of academic integration aspects (Scalise et al, 2000; Allen, 1999).

Tinto initially conceptualized that the student is responsible for ensuring the realization of a good fit between the institution and the student. In this regard, a student having poor academic and social integration was most likely going to drop out. However, the theory was later changed by recognizing the institutional culture as being one of the factors that encourage students to remain dedicated to their course (Tinto, 2007). One weakness that was identified by the Tinto is that it does not address policy guidelines and programs to streamline institutional action towards better social and academic integration. Kubiak (2005) adds that the Tinto's model is consistent with Fiegenbaum's explanation of value added quality. In reference to the first year student success model, Tinto's model supports the need to have an effective engagement between professor's and first-year engineering students to ensure success (Tinto, 2006; Tinto, 1993). Indeed, this is an important point where members of the teaching staff connect with the first-year engineering students.

2.4 DEVELOPMENT OF A RETENTION MODEL FOR FIRST-YEAR ENGINEERING STUDENTS

The Tinto model was essentially used as a base model to design a new model for first-year engineering success. This model focuses on the attributes of retention as well as academic success. This model is essentially portrayed in Figure 5.

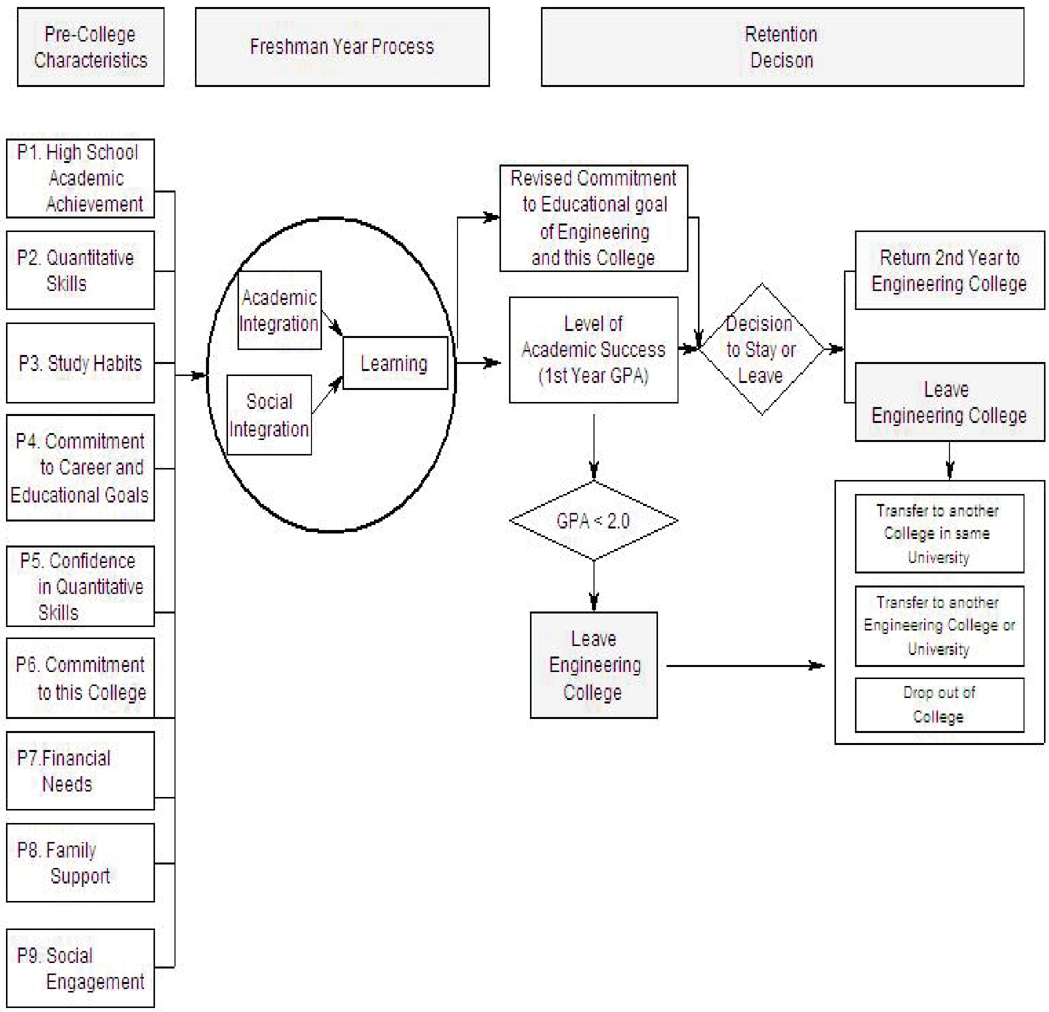


Figure 5. Illustrating a block diagram for First-Year Student Engineering Success (Veenstra, 2008)

2.4.1 Pre-College Traits

This section focuses on the some of the pre-college traits that play a major role in determining the student success model. In order to accomplish the goals of this section, the following subsections were developed:

i. 2.4.1.1 Literature review process

ii. 2.4.1.2 Comparison between the literature review and Tinto model

iii. 2.4.1.3 Literature review findings

iv. 2.4.1.4 How student success in engineering education varies from other disciplines and how this influences the first year engineering student success model

2.4.1.1 Literature review process

Figure 6. provides the process that was followed in accomplishing the literature review.

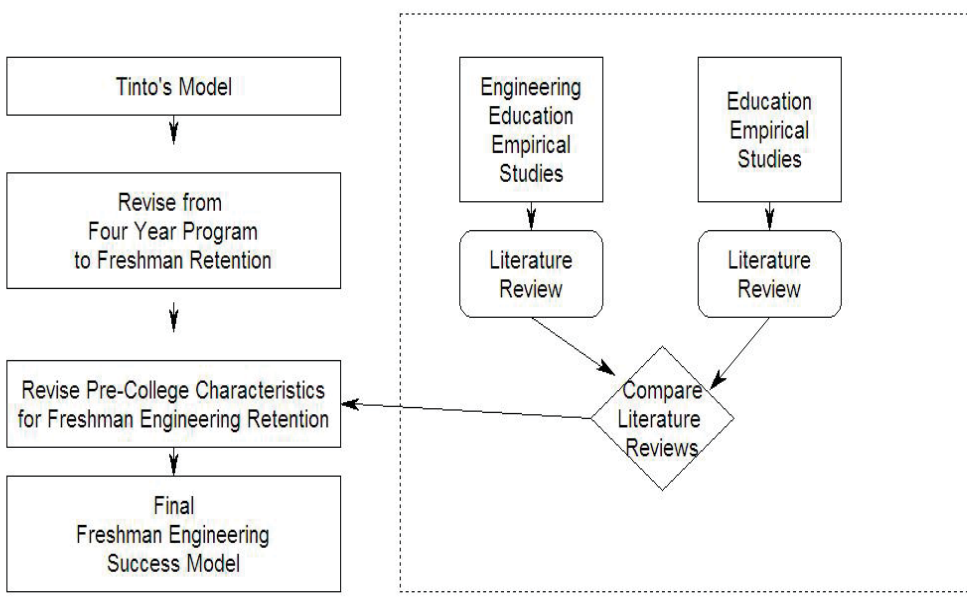


Figure 6. Process of developing in the First-Year engineering student success model (Veenstra, 2008)

This model enabled the study to begin by focusing on a wide option of variables. Since there are limited educational materials focusing on the first-year engineering student success, this ensured that the reviewed information from education research and retention studies (4-6 years). These enabled the development the variables used to define student success. The Tinto model's defined precollege characteristics were essential in choosing the variables.

2.2.1.1 Tinto's Model's Pre-college Characteristics

The definitions of precollege characteristics provided by Tinto's model were essentially used as a guideline in the current research. According to Tinto (1993), students join institutions of higher learning with different backgrounds informed by attributes like social status, community size, and level of parental education. Students also come with a range of personal attributes such as race, sex, and physical handicap (Tinto, 1993). There are unique skills that accompany the students and these may either be social or intellectual. Some students come from families with limited financial resources while others from rich background. Students may also have unique dispositions such as political affiliation, motivation, or intellectual (Tinto, 1993). There are students who may have achieved high or low GPA at the high school level. Additionally, Tinto (1993), adds that students have different intentions and goals, and one' level of commitment to these goals may influence occupational choice and type of institution in which they gain entry. In essence, Tinto's model categorizes commitments and goals differently from student pre-entry traits. However, in the first year engineering student success model, these are included as a part of the pre-entry traits. Additionally, in the first-year engineering student success model, gender and race were eliminated because the aim was to propose a unifying model for all genders and races.

2.2.1.2 Literature Review Supporting Precollege Traits

Pillar1. High School Academic Achievement

Academic and non-academic variables were taken into account in developing information for the literature review. The analysis showed strong support for the rank and high school GPA as good indicators for academic variables. High school GPA can be used to model first-year engineering student success or retention (Lackey et al., 2003; Levin & Wyckoff, 1998). It has also been used as a variable in some first-year education success and retention studies (Williamson & Creamer, 1988; Glynn et al., 2005).

On the contrary, some studies have focused on the influence of GPA on other levels as well. For instance, another study established that there is a big difference in terms of high school GPA between students who returned in the second-year and those who left after the first-year (Burtner, 2004). Additionally, some scholars believe that high school GPA plays a major role in the advanced years in college engineering. For instance, some studies indicated that academic success and retention in the upper engineering classes shows that high school GPA is a predictor (Zhang, et al., 2004; Astin & Astin, 1992).

On the other hand, previous engineering retention and success studies have indicated that high school ranking plays a significant role (Scalise et al, 2000; Besterfield-Sacre et al., 1997). Retention refers to progression to the next level while success refers to high achievement. The same has also been observed in first-year education retention and success studies (Allen, 1999; Terenzini et al., 1985). In another study focusing on upper class division retention and success, it was established high school ranking was a predictor (Besterfield-Sacre, 2002; Moller-Wong & Eide, 1997; French et al, 2005).

However, Scalise et al. (2000) observed that SAT total scores was a major predictor of first-year engineering class retention. In other first year education studies, it was also established that the ACT composite score played a major role in determining retention (Terenzini et al., 1985; Tinto, 1993; Pike et al., 1997). In the upper division engineering segment, it was also established that SAT Total and ACT composite scores play some role (French et al, 2005; Padilla et al., 2005; Eide and Moller-Wong, 1997). The same was also observed in upper division education studies (Astin and Osuguera, 2005; Tinto; 1993).

Meta-analysis of another 109 studies focusing on college and university retention also indicates that ACT scores, high school GPA are major predictors of retention and success (Robbins et al., 2004; Lotkowoski et al., 2004). In another study focusing on numerous institutions, provided evidence showing that ACT scores and high school GPA have a strong correlation with college GPA (Seidman, 2005). It is important to note that even though SAT/ACT scores are major predictors for students to continue in engineering based on previous studies, in the current study it will not be included because of the inconsistency of SAT/ACT scores in our database.

Other studies indicate moderate support for non-academic attributes as playing a role in retention and success in engineering studies. Self-confidence was specifically identified as having a strong correlation with retention and good college GPA (Robbins et al, 2004; Lotkowski et al., 2004). Another study indicates that self-confidence in speaking and writing skills was a significant determinant of attrition among engineering students (Besterfield-Sacre et al, 1997). This study showed that those engineering students who left engineering had average scores in communication skills while students who stayed in engineering had high scores in communication skills.

Pillar 2. Quantitative Skills

Research studies show that those SAT and ACT scores in math are important in determining student success in engineering education. Empirical studies focusing on first year engineering indicate that SAT and ACT scores in math are major predictors when it comes to determining retention and success (Wyckoff, 1988; Besterfield-Sacre et al., 1997; Leuwerke et al., 2004; Lackey et al., 2003). Another study focusing on performances in upper class engineering shows that ACT and SAT math scores are an effective predictor of retention and success (Moller-Wong & Eide, 1997; Zhang et al, 2004; Astin & Astin, 1992; Besterfield-Sacre et al., 2002; French et al., 2005). It has also been established that placement test scores play a significant role in establishing retention and success in engineering education (Budny et al, 1998; Levin and Wyckoff, 1988; Besterfield-Sacre et al., 2002). Adelman (1992) observed in his multi-institutional study that the highest level of math that a student studies while in high school has a major influence towards his completion of the bachelor degree. Astin and Oseguera (2005) supported this by showing that the number of years spent on math in high school was a major predictor towards graduation rate prediction.

Pillar 3. Study Habits

Studies show that the study habits play a significant role in determining retention and success in first-year engineering studies (Tinto, 1993; Donovan, 1984;

Glynn et al., 2005). Indeed, the number of hours per week that a student dedicates towards studying in high school is critical in determining student retention and success (Besterfield-Sacre et al., 1997; Levin and Wyckoff, 1988; Burtner, 2004; Scalise et al., 2000). It has also been established the hours that a student spends in their high school studies is a significant determinant of a successful six year graduation (Astin and Oseguera, 2005). Time management is another attribute of study habits that has been established as playing a major role in enhancing college retention and GPA scores (Robbins et al., 2004). In 3-4 retention studies, it was established that retention was negatively affected by faculty integration, but student integration led to an opposite reaction (French et al., 2003). This was an important aspect towards learner-teacher engagement at high school level. A follow up study discovered that there was more positive effect on retention resulting from learners talking to teachers outside the class environment (Astin and Oseguera, 2005). In a cohort study, an interesting relationship was established among studying pattern with friends, teacher help, and achievement of extra credit in high school played a significant role in determining retention (Glynn 2005-2006). Independent learner traits were also established as being a good factor in engineering education because they are able to demonstrate better responsibility in their learning and they make the learning environment favorable (Astin and Astin, 2000). Other aspects that affect good study habits in high school and college included frequency of reporting late to class. Indeed, it was established in a study that the probability of students being placed on academic probation was frequent among students who had a high frequency of reporting late to class than students who had a low frequency (Shumann et al., 2003). In another 303 Higher Education Research Institute (HERI) college study, it was established that frequency of coming late had an impact on the 4-6 year retention (Oseguera, 2005-2006). In a follow up study focusing on students who transferred out of engineering, it was established that 37% were not emotionally prepared to handle the rigorous engineering curriculum (Shumann et al., 2003).

Pillar 4. Commitment to Educational and Career Goals

According to studies conducted by Besterfield-Sacre et al (1997), Burtner (2004), and Hartman and Hartman (2006) students who tend to have a positive impression about engineering as a career have a better first year engineering retention rate. Students who have intrinsic interest towards engineering tended to have college GPA scores and the difference is at 0.14 compared to those students who are engineering because of the high pay associated with the career (Levin and Wyckoff, 1988). Another study established that students who were positively oriented towards engineering as a career through effective theoretical contributions in their first year engineering actually had better graduation rates than their counterparts (Astin and Astin, 1992; Moller-Wong and Eide, 1997). First-year engineering students who had more of their peers in engineering courses in first year level or parents who are engineers tended to have better retention rates (Seymour and Hewitt, 1997; Astin and Astin, 1992). First-year engineering students who joined engineering courses because of the perceived attractive pay at the end of the course switch majors on to other courses if their academic performance was low (Besterfield-Sacre et al., 1997; Seymour and Hewitt, 1997). Studies focusing on upper division college retention established that having a positive personal drive to achieve high scores with an aim of joining graduate school led to better retention (Astin and Oseguera, 2005). Personal motivation is also a factor that improves retention among upper division college engineers (French et al., 2005). Another study used the Hexagon Congruence Index (HCI) and ACT math scores to examine first year engineering retention (Leuwerke et al., 2004). HCI was essentially used to establish the congruence between an engineering career and the perceived individual interests of the 844 students that participated in the study. The study established that having a strong interest in engineering is not sufficient because retention weights more towards math achievement. This is because more students who had high math scores remained in engineering compared to those who had a higher interest (Leuwerke et al., 2004). The study also established that when the interest of students who had high math scores was improved, the probability of retention was significantly increased. On the other hand, students who had less interest, lower ACT scores, and lower college GPA had a high probability of leaving engineering. The study also established that gender and ethnicity did not play a major role in determining the attrition rate (Leuwerke et al, 2004).

Pillar 5. Commitment to College

Commitment among first engineering students to their choice of college can be used as a predictor of first year engineering retention. In a multi-institutional study, it was established that a student's choice of college did not play a major role in influencing their persistence in the engineering career (Astin and Astin, 1992). Nevertheless, other studies show that a student's commitment to their college or university had a positive correlation with first year engineering retention (Lotkowski et al., 2004; Pascarella and Chapman, 1983; Robbins et al., 2004; Glynn et al., 2005). Thus, it implies that personal motivation and a will to manage the rigorous engineering curriculum determines the success of first-year engineering students.

Pillar 6. Financial Needs

Previous retention studies indicate that access to financial assistance is an important predictor of retention and success in engineering studies. (Brainard and Carlin, 1998, Astin and Astin, 1992; Johnson and Sheppard, 2002). Indeed, students who secured scholarship had better first term GPA during their first-year (Besterfield-Sacre, 1997). Another study pursued a causal model to establish that access to financial aid had a direct influence on a student's first year GPA; however, this did not positively influence their retention levels (Allen, 1999). Additionally, in another Higher Education Research Institute (HERI) study, it was established that students who were constantly worried about their ability to pay for their college tended to have lower retention rate (Astin, 2005-2006).

Pillar 8. Family Support

A study by Seymour and Hewitt (1997) reported the power of the influence of family members when students are deciding whether to enroll or not enroll in engineering college. The study revealed that students' concern about their parent's earning potential in other fields and their commitment towards paying their fees inspired them to stay on. Family support also plays a major role when it comes to retention (Tinto, 2006; Elmers and Pike, 1997; Pike, Schroeder and Berry, 1997). Other studies have also established that education level of a parent plays an important role in determining retention (Glynn, 2005-2006; Oseguera, 2005-2006). Encouragement from family members and friends also played a role in first-year retention (Nora, Cabrera, and Castaneda, 1993). This support and encouragement is essential during the first semester. Hence, it is important for higher learning professionals to involve parents and friends in the first semester in order to play a role (Elkins, Braxton, and James, 2000).

Pillar 9. Social Engagement

According to Astin's theory of involvement, it is important for students to involve themselves in social activities such as volunteer organizations and clubs (Astin, 1984). A student who participates in these activities becomes more integrated. A recent study revealed that students became more attached to the institutional values when they're participated in community work (Astin and Oseguera, 2005). Social involvement has also been associated with better retention and higher college GPA (Lotkowski et al., 2004).

2.2.1.3 Variation of Student Success in Engineering Education from Other Disciplines and How This Influences the First Year Engineering Students Student Success Model

The role of this section is to show how the process of achieving success among engineering students is different from what other students experience in other disciplines and how this influences the experiences and success of first-year engineering students. This will be covered in the topics below:

Role of Engineers in Technology Enhancement and Design

The engineering curriculum focuses on fulfilling the engineer's role and purpose in society. A competent engineer should be able to solve problems through innovation and production of new product designs. It is this need for constant innovation that makes them special place in the society. To be able to this, an engineering student should be an analytical thinker who aims at developing new design systems and innovation.

The Engineering Program

The engineering program is designed to propel students towards achieving their professional career. Similar to other programs such as medicine or business, the engineering program also has well defined career goals. These goals require a functional student success model to guide them towards a definitive career in engineering.

Math and Science in the Engineering Curriculum

Math and science play a very fundamental role in engineering. This is because of the analytical and technical approach employed in engineering. The way the engineering curriculum has been structured, students are required to take more science and math based pre-college courses compared to other programs such as liberal arts. This implies that the retention of engineering student is highly dependent on the performance of engineering students in these courses.

First-Year Engineering Grading

Astin (1993) claimed that engineering students tend to have lower GPA points compared to students in other courses. This implied that students who have better performance in math and science are better competitors than their counterparts with weak science and math performance. As a result could lead to a higher percent of engineering students on academic probation after the first year. However, a more recent study by Ohland (2008) et al. does not support this view.

Common Assumptions between First Year Engineering Students and Other Programs

i. An engineering major essentially prepares the student for a career in engineering. Professionals programs also do the same; however, liberal arts and science programs tend to focus less on a well-defined career.

ii. An engineering program aims at strengthening the problem solving and analytical skills, consequently necessitating an intense science and math program during the first-year engineering students year.

iii. Admission in an engineering program tends to have more pre-college preparation science and math courses than other programs

These assumptions were considered in developing the first year engineering student engineering success model. The fourth pillar outlines engineering alignment to career objectives. The second pillar focuses on aspects of engineering curriculum with regard to acquisition of analytical skills and technology. The first pillar focuses on issues regarding math and science based pre-college courses. Additionally, the pillars also address the assumption that the grading mechanism is different indirectly connected to the attributes of student success.

2.2.1.4 First-Year Engineering Process and Its Impact on Successful Learning

Academic integration generally focuses on the performance attributes of the student while social integration focuses on the level to which a student cultivates a good relationship with faculty member and other peers. Looking at the Tinto model, it is evident that it is not based on the assessment that the experience of First-Year engineering students in the community is influenced by attributes of social and academic integration, (Tinto, 2006).

Increased Commitment towards Continuing Engineering Degree

It has been established in the Tinto model that when students begin their studies, they tend to review their academic and career goals (Tinto, 1993). This concept has been reinforced in the Watson and Froyd engineering education model, which labels this as an interference effect that, affects the link between career goals, cognitive performance, and self-identity (Watson, 2007). Adelman also gave a similar observation in his study focusing on the path towards attaining engineering major (Adelman, 1998). This is mainly observed among students intending to pursue either science or math majors. When the student is doing this review, they also tend to reevaluate their institutional commitment level. In this regard, those students who had integrated at social as well as academic levels tend to portray a higher probability of staying. Nevertheless, in my literature review I did not find sufficient evidence focusing on attributes of an engineering career with regard to retention.

Decision to Leave or Stay in an Engineering Program

This essentially focuses on the retention levels of engineering students at the end of their first-year engineering students. According to Veenstra (2008), it can be expressed in four states as follows:

i. Engineering students make a decision to stay
ii. Engineering student leaves or transfers to another program in the same institution
iii. Engineering student leaves or transfers to another university or engineering college
iv. Engineering student decides college isn't what they want and leaves completely

Impact of Low GPA and Academic Probation on Student Decision to Leave

The case among students who are not prepared to handle the math and science rigor that they are subjected to it was observed that students who earned less than a grade C tended in the first two terms ended to leave engineering. In Tinto's model, more focus was given to students leaving engineering voluntarily but it did not explicitly focus on academic probation (Tinto, 1993).

How Society Defines Loss?

This will be depicted in Figure 7, which illustrates loss function based on retention:

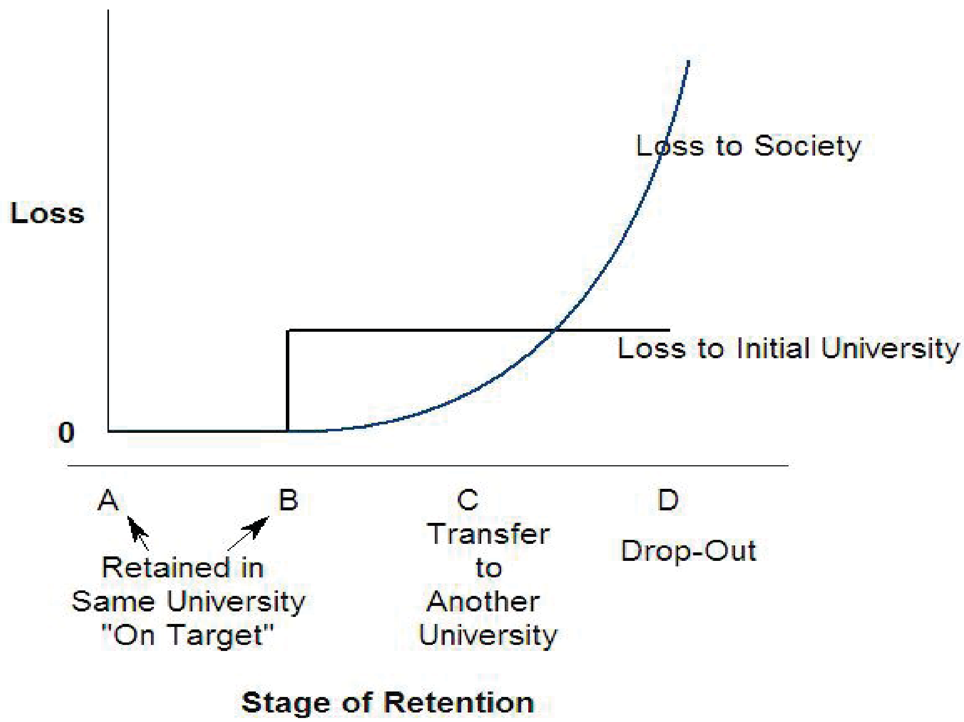


Figure 7. Illustrating Loss With Regard To Retention Or Attrition Among Engineering Students (Veenstra, 2008)

States A and B show that the student appreciates the investment put by the institution by staying in their respective engineering programs; hence, there is no loss. The first-year engineering students year is essentially a time when students are still making up their minds on whether to proceed or not. State C shows that a student decides to leave the engineering progra and instead transfers to another engineering college or univeristy. In this state, the student is still relevant in the program and will add value to the society. State D shows that after the first year, the student decides to drop out. This results in a loss in the society as well as the engineering program investment.

2.5 Summary

In essence, the thesis of the paper states that first-year engineering students is not the same as general college retention. To arrive at this, a review of the present engineering models was carried out with the sole aim of developing a first year engineering students retention model that derives pre-college characteristics expressed in the Tinto model. This model has enjoyed wide acceptance from education researchers for a period of 30 years. The components that are essentially expressed in the first year engineering students retention model are illustrated in Figure 8 below:

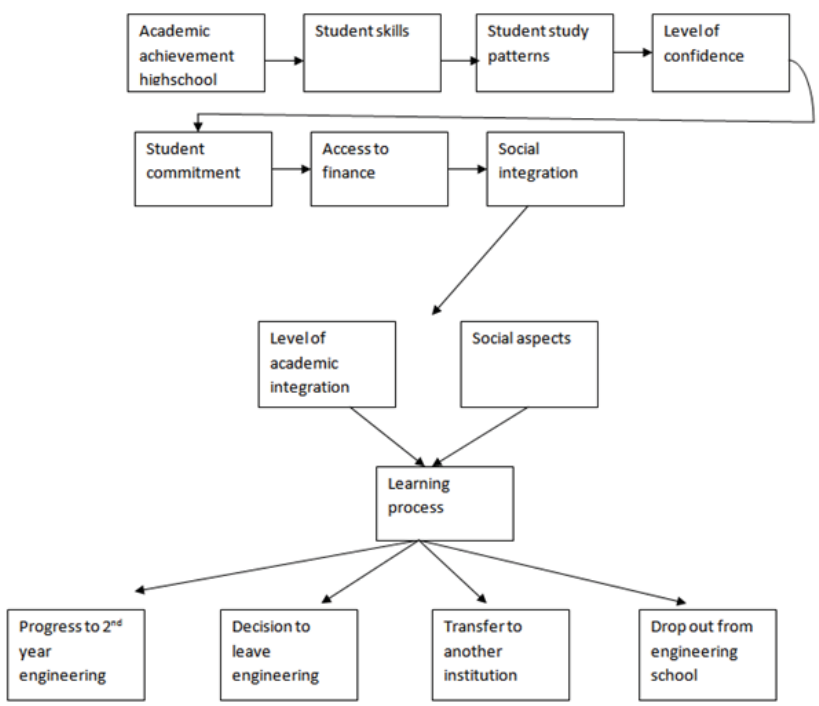


Figure 8. Illustration of the First-Year Engineering Students' Success Model

3.0 METHODOLOGY

The accuracy of the outcomes from any statistical model is primarily determined by the data and method pursued in examining the data. In this regard, the following will be used:

First model: Students retained in Engineering after the first-year will be the dependent variable while the students' engineering performance will be used as the independent variables.

Second model: the period it takes (in terms of years) to successfully complete and graduate from an engineering program will be used as the dependent variable while the GPA attained during the first-year and model variables and engineering performance will be used as the independent variables

Regression analysis has previously been identified as a suitable method for modeling college GPA (Levin & Wyckoff, 1988; Besterfield-Sacre et al., 1997). In this research regression analysis is applied because it enables the researcher to control the precollege characteristics in particular dichotomous variables. Additionally, logistic regression modeling has been used in many prior studies as well (French et al., 2005; Levin & Wyckoff, 1988; Astin & Astin, 1992; Scalise et al., 2000; Besterfield-Sacre et al., 1997).

3.1 ETHNICITY AND GENDER DIFFERENCES

In the recent past, there has been an increase in the number of engineering students from traditionally underrepresented groups such as minorities (non white) and women groups. As such, it will be important to determine whether retention is statistically different from that of majority student cohort. In this regard, a generalized linear model was used to establish the existence of statistical differences in the identified variables.

The participants used for the study students from YSU who had enrolled in the course Engineering 1550 from 2005-2012. This study also intends to examine the factors responsible for predicting the likelihood of a student joining a STEM program or an ABET accredited Engineering program to complete studying in the same institution. This will allow the study to examine the current recruitment strategies being employed in the campus setting in order to offer proper advice to staff members in the institution. Nevertheless, the study fails to identify the occurrence of challenges experienced and it also does not analyze the present recruitment and retention strategies. The main intention is to identify differences to improve retention.

3.2 RESEARCH DESIGN AND TARGET STUDIES

The first component of the research is a quantitative analysis focusing on 1238 YSU Engineering1550 graduates from 2005 till 2012 and it pursues discriminate analysis on the data for every participant. In this analysis, the matriculation or non-matriculation of a student will be the dependent variable. The independent variables will be race, gender, calculus I grade, total number of days taken to graduate, GPA earned at first semester, and grade earned in Engineering 1550. Days were converted into years for more precision in analysis.

3.3 DATA COLLECTION AND ANALYSIS

Institutional Research provided the data for the current study. Among the variables collected included student's demographic information and academic performance record. The data were then grouped into three main categories as follows:

- Continuous enrollment in same institution
- Drop Out from the STEM program (this consisted of students who initially started in a STEM program but failed to completed their studies).
- Engineering graduate (refers to a student that successfully completed studies and graduated in Spring 2009-2013)

4.0 DATA ANALYSIS

This study uses First-Year Engineering students from the Institutional Research database at Youngstown State University. Historical student records were analyzed from 2005-2012 in order to understand research questions related to persistence and retention. Logistical Regression was used to identify academic factors that predict engineering student's graduation and retention rates.

4.1 ANALYSIS ON ENGINEERING POPULATION

The data analysis of 1238 students enrolled in the ENGR 1550 course from 2005 to 2012 is presented in this section.

Table 2 shows that from 2005 to 2012, enrollments in ENGR 1550 increased over time. The interesting feature is that the female count in 2009 was the lowest at 12; however, the male enrollment was stable through out the years ranging from 106 to 176.

Table 2. Count of All Students Enrolled in ENGR 1550 (Engineering Concepts) 2005-2012

Gender	2005	2006	2007	2008	2009	2010	2011	2012	Total
Male	106	123	127	123	120	143	147	176	1065
Female	20	20	23	24	12	21	21	32	173
Total	126	143	150	147	132	164	168	208	1238

Table 3 shows that from 2005 to 2012, more men than women enrolled in ENGR 1550. In 2009, 91% of the population was men compared to 9% female. Based on the data from table 2, in 2009, women had the lowest enrollment with 12 students compared to other years.

Table 3 Percentage of All Students Enrolled in ENGR 1550 (Engineering Concepts) by year 2005-2012

Gender	2005	2006	2007	2008	2009	2010	2011	2012
Male	84	86	85	84	91	87	88	85
Female	16	14	15	16	9	13	13	15

Table 4. shows the significant differences in gender success in engineering.

Based on the 95% confidence interval and p-value, we conclude that there is a significant difference between the overall male and female ratio. Thus, there were more female engineers retained to graduation than males. In addition, there is a significant difference between the male and female ratio; which shows that female engineering students take longer to graduate from engineering then males. On average it takes females 4.39 years to graduate and 4.28 years for males.

On the other hand, based on the 95% confidence interval, there is a no statistical significance between continuing male and female ratio.

Table 4. T-Test Results for Gender Success in Engineering

Retention to Graduation Rate	Ratio	Difference to Overall R (1) - R (2)	Difference of Male and Female R(1)-R(2)	P-Value	P-Value	Significance
Overall	0.2132					
Male	**0.1962**	0.1962-0.2132=-0.0170		0.313		Not Significant
Female	**0.3179**	**0.2132-0.3179= -0.1046**	**0.1962-0.3179=-0.1216**	**0.005**	**0.001**	**Significant**
Retention to Enrollment Rate	**Ratio**	**Difference to Overall R (1) - R (2)**	**Difference of Male and Female R(1)-R(2)**	**P-Value**	**P-Value**	**Significant**
Overall	0.2763					
Continuing Male	0.2789	0.2763-0.2789=-0.0026		0.889		Not Significant
Continuing Female	0.2601	0.2601-0.2763=-0.0161	0.2601-0.2789=-0.0188	0.651	0.603	Not Significant

Figure 9 shows the number of male and female students who enrolled for ENGR 1550 from 2005 to 2012. From the graph, it is evident that there has been a gradual increase in the enrollment, especially among males. This implies that there is a gender parity issue in enrollment.

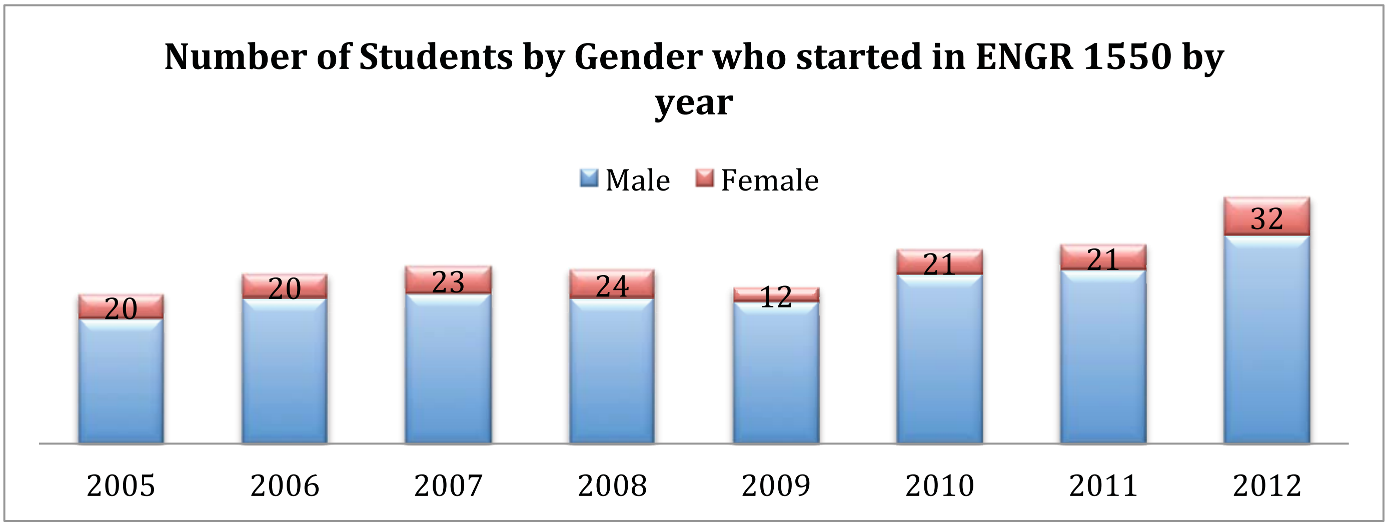


Figure 9. Number of Students by Gender who started in ENGR 1550 by year

This table 5 shows that more whites enrolled than any other racial group. It also shows that less non-resident women enrolled compared to non-resident males. Additionally, less female racial minorities enrolled than males. This also included Blacks, Hispanics, and Asians.

Table 5. Number of Male and Female Students by Racial Group Enrolled in ENGR 1550 (Engineering Concepts) 2005-2012

Gender	Black	Hispanic	Asian	Non-Resident	Unknown	White	Multiple	Other	Total
Male	37	29	10	14	82	886	6	1	1065
Female	8	7	4	1	9	140	3	1	173
Total	45	36	14	15	91	1026	9	2	1238

Table 6 shows the percentage of minority vs. majority of students who were enrolled in ENGR 1550 from 2005 to 2012. The percentage of minority students ranged from 4 to 11 percent. In 2009, minority female students were at the lowest for enrollment compared with to other years. In this data, students belonging to other races apart from whites represent minority students.

Table 6. Percentage of Minority and Majority students enrolled in ENGR 1550 by year

Ethnicity	2005	2006	2007	2008	2009	2010	2011	2012
Minority	8	9	7	6	4	9	10	11
Majority	92	91	93	94	96	91	90	89

Figure 10 shows the percentage of minority and majority of students enrolled in ENGR 1550 from 2005 to 2012. The data shows that more students from the majority racial group (White) enrolled for the ENG 1550 course every year compared to students from minority racial group.

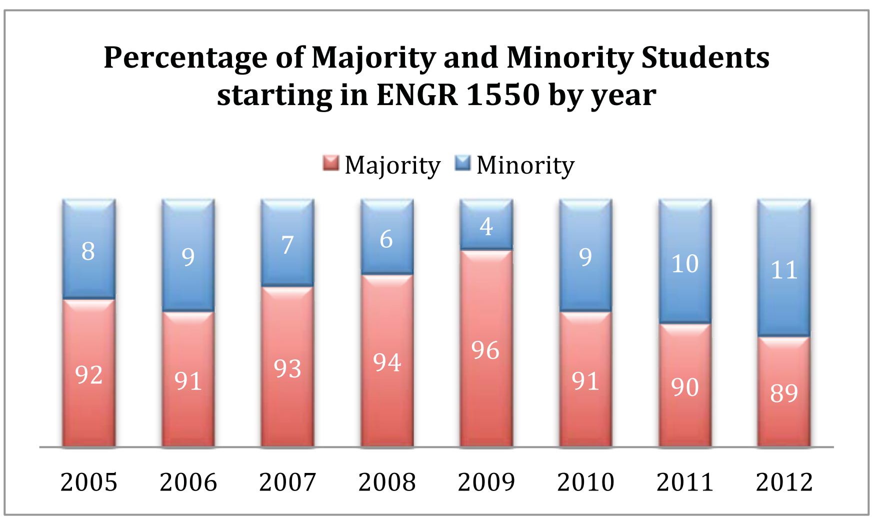
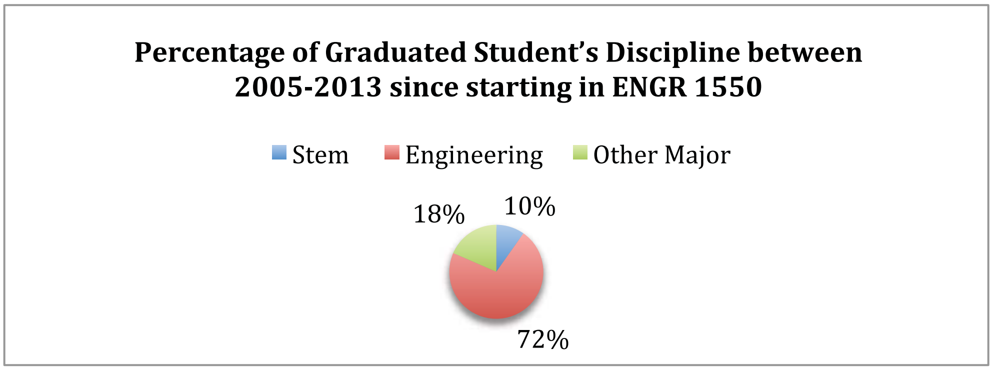


Figure 10. Percentage of Majority and Minority Students enrolled in ENGR 1550 by year

Figure 11 shows the total number of students who graduated from YSU after enrolling for ENGR 1550 from 2005 to 2012. Engineering is the highest at 72%

compared to other majors and STEM. The enrolments in statistics for engineering was higher then STEM, with 65% of students completing their degree in four years, 28% completing their degree in five years, and 7% completing their degree in six years.

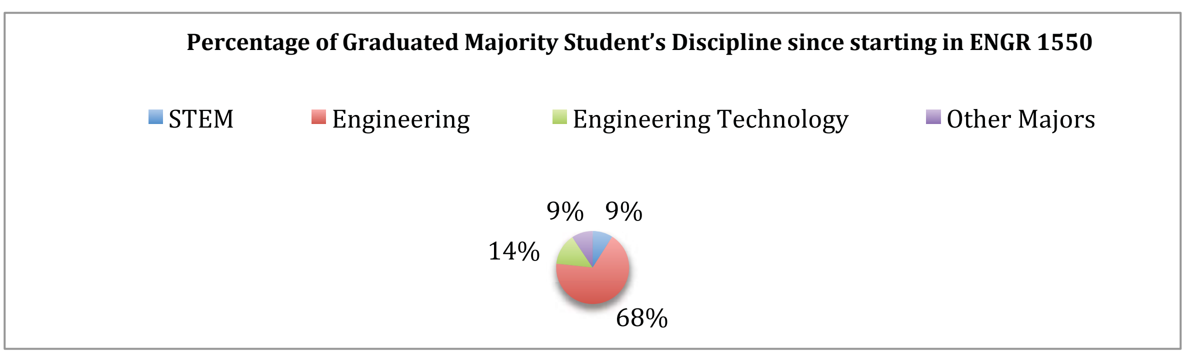


Total number of students: 370

Figure 11. Percentage of Graduated Student's Discipline between 2005-2013 since starting in ENGR 1550

4.2 MAJORITY DATA ANALYSIS

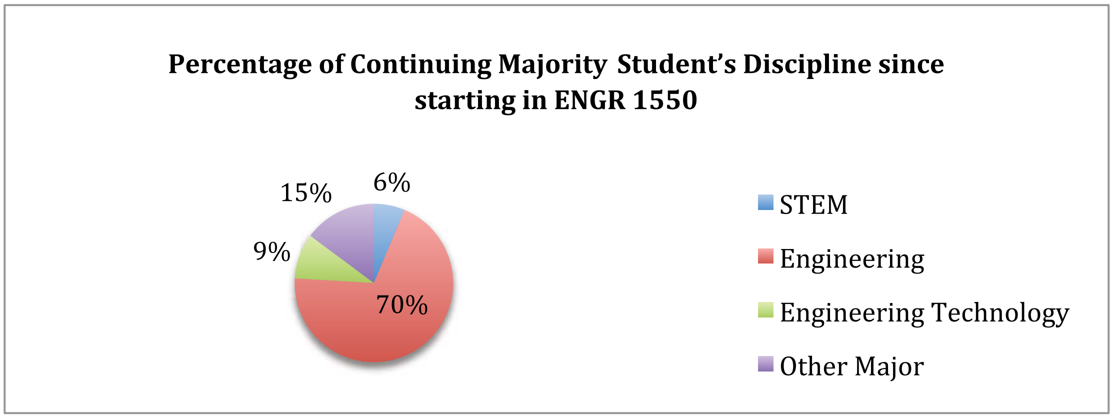
Figure 12 shows that out of the 321 students that graduated from YSU after taking ENGR 1550, engineering students were the highest with a 68% representation while engineering technology students were second with a representation of 14%.



Total number of students 321

Figure 12. Percentage of Graduated Majority Student's Discipline since starting in ENGR 1550

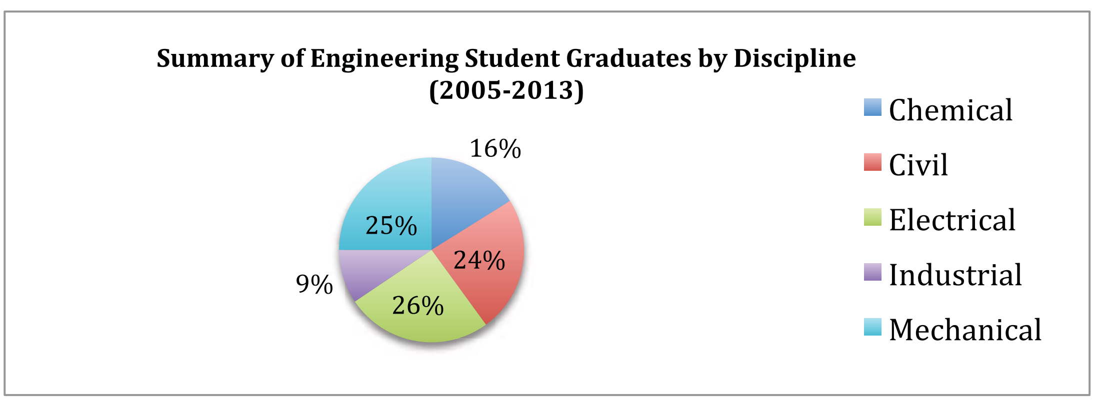
Figure 13 shows 444 students continuing undergraduate students enrolled at YSU. The highest percentage of continuing students is engineering 70%; however, other majors (including non-STEM majors) were second highest at 15%.



Total number of students 444

Figure 13. Percentage of Continuing Majority Student's Discipline since starting in ENGR 1550

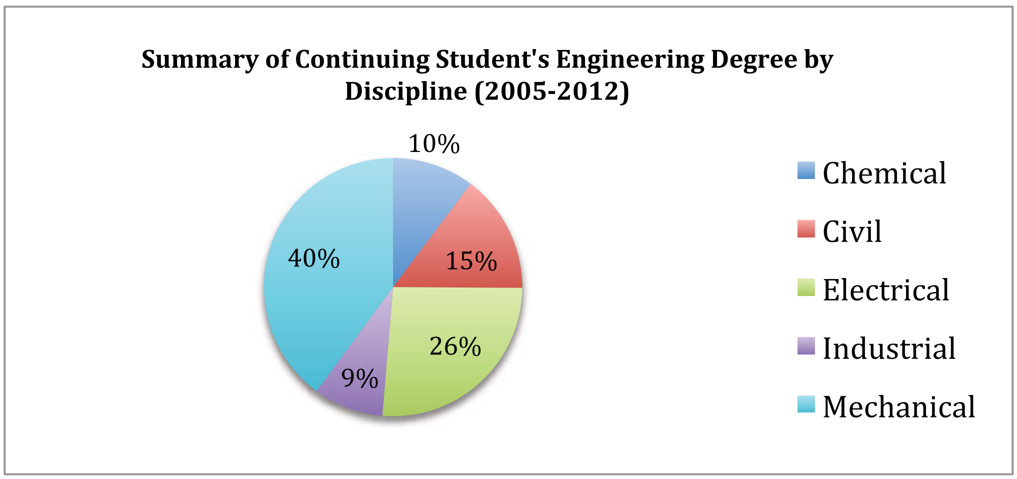
Figure 14 shows the breakdown of the 224 students by engineering discipline who graduated from YSU between 2005and2013. From this, 25% came from Mechanical Engineering, 24% Civil Engineering, 26% Electrical Engineering, 16% Chemical Engineering, and 9% from Industrial Engineering.



Total number of students 224

Figure 14. Summary of Engineering Student Graduates by Discipline

Figure 15 shows the percentages of students continuing towards an engineering degree. Of the 302 students who took ENGR 1550 between 2005and 2012, 40% were Mechanical, 26% Electrical, 15% Civil, 26%, 10% chemical, and 9% Industrial Engineering. Comparing these percentages to the students who graduated during the same time period, Mechanical Engineering accounts for only 25% of the students. Based on enrollment in Figure 16 shows that Mechanical Engineering had 118 incoming students, which was the highest number of compared to other engineering majors.



Total number of 302

Figure 15. Summary of Continuing Student's Engineering Degree by Discipline (2005-2012)

Figure 16 shows the number of students (both majority and minority) still pursuing a Bachelor's Degree in Engineering. This figure shows that Mechanical Engineering ha the largest number of incoming students and also the largest number of male students. However, electrical had the second highest number of incoming students while Chemical Engineering had the highest number of incoming female students. This figure validates the elevated percentage of students that were continuing in Mechanical Engineering but had not yet graduated.

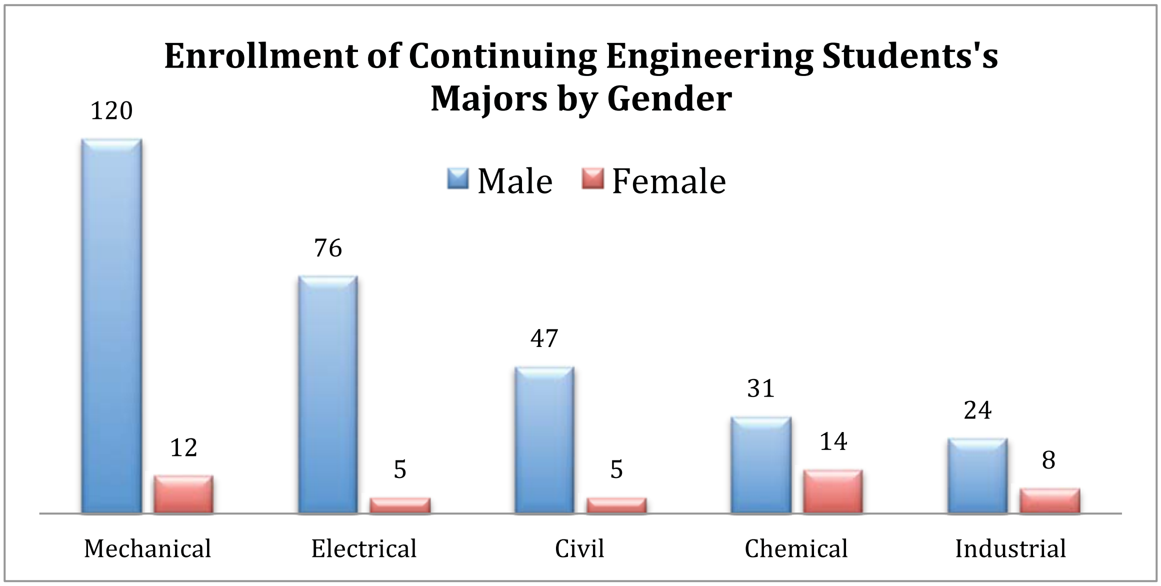
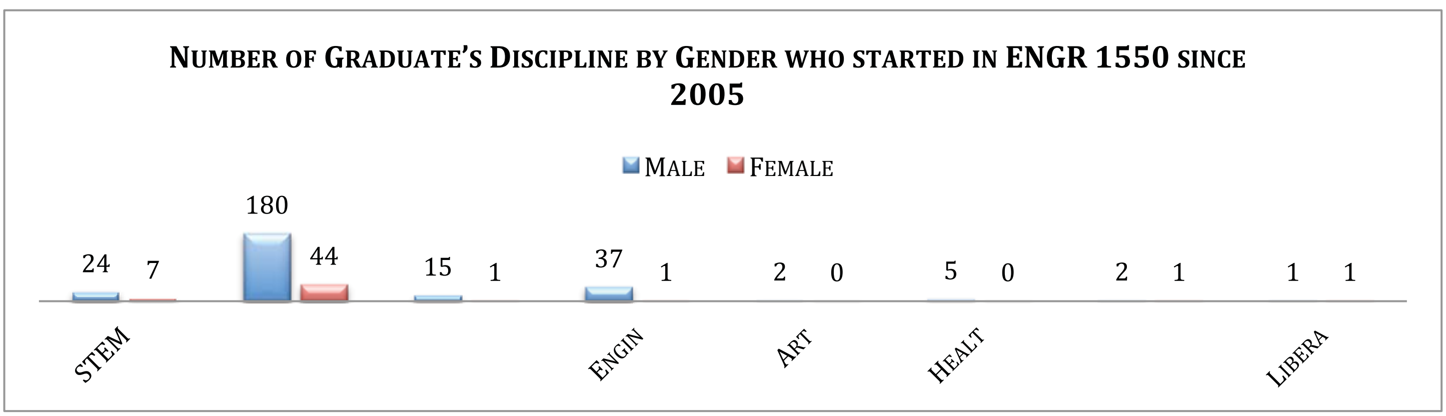


Figure 16. Enrollment of Continuing Engineering Student's Majors by Gender

Figure 17 illustrates gender frequency in the number of students pursuing different graduate disciplines who took ENGR 1550 since 2005. The graph shows that most of the students who enrolled were males. It is also evident that students who do not continue in engineering join technology at a higher rate than other majors.



Total number of students 224

Figure 17. Number of Graduate's Discipline by Gender who started in ENGR 1550 since 2005

Figure 18 shows the frequency of students continuing towards degree completion by major and gender that took ENG 1550 between 2005 and 2012. Engineering was the highest discipline having the highest enrollment for both genders among other majors.

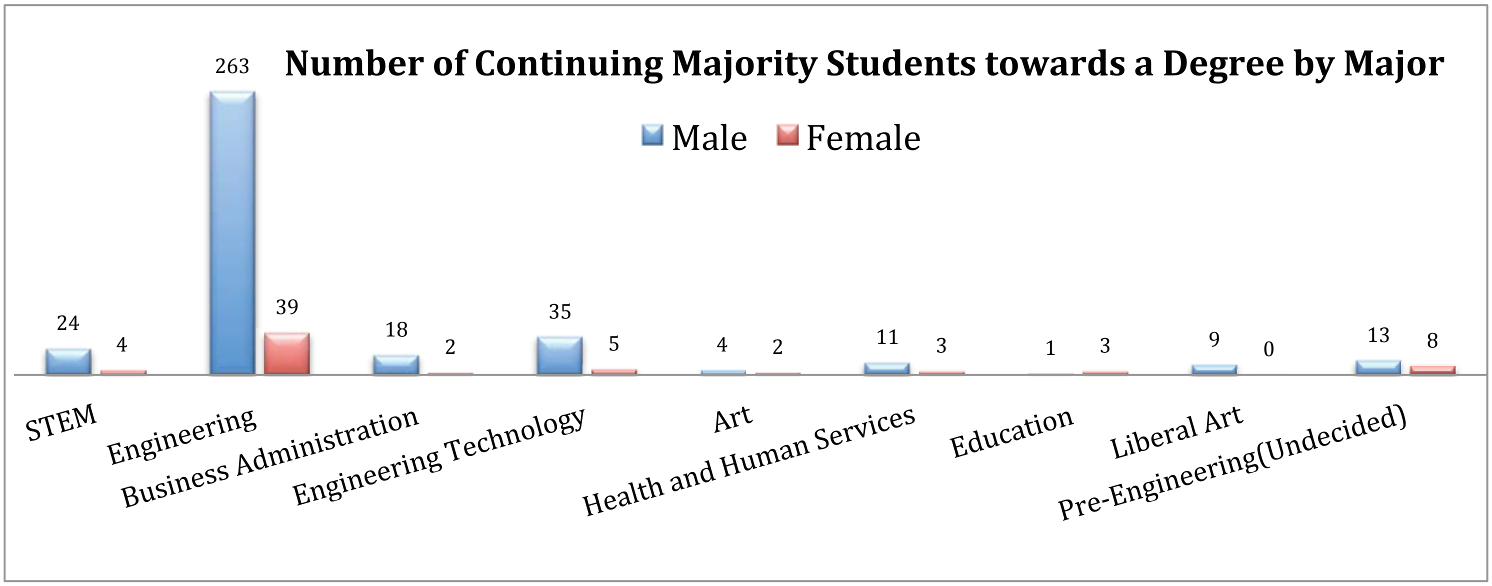
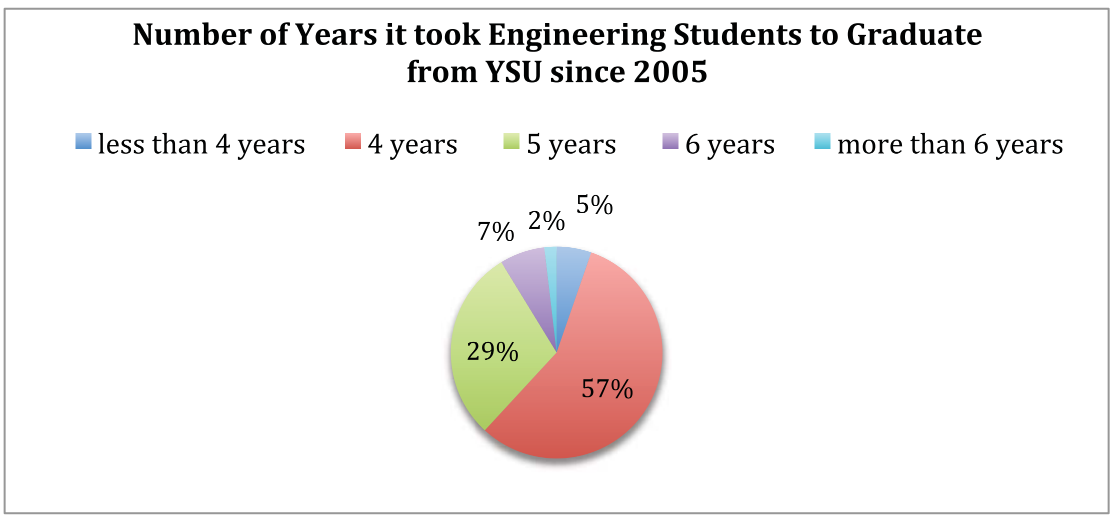


Figure 18. Number of Continuing Majority Students towards a Degree by Major

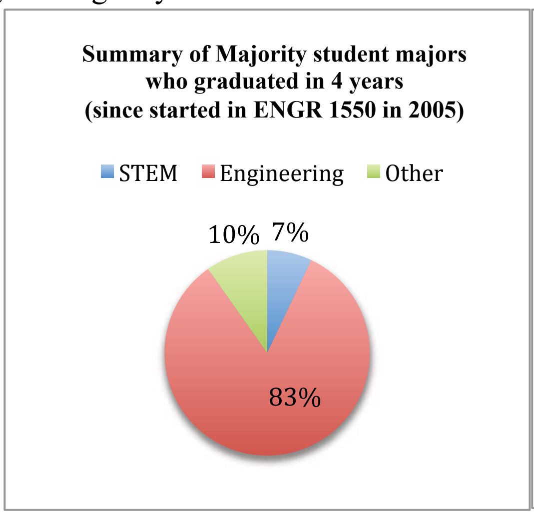
Figure 19 shows the number of years it took for majority students to graduate. 62% graduated in 4 years or less, 29% graduated in 5 years, and 9% graduated in 6 or more years. The average time for majority students to graduate was 4.23 years.



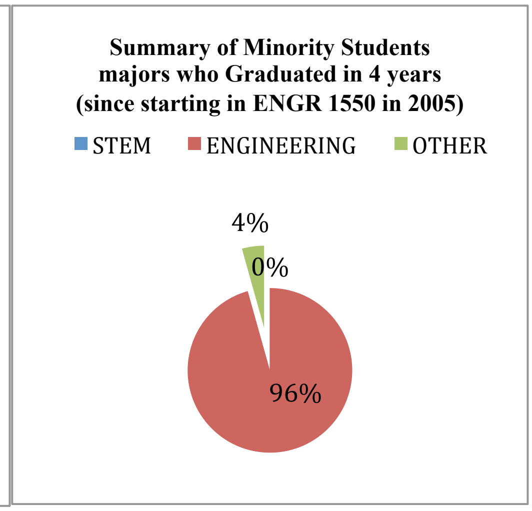
Total number of graduate is 321

Figure 19. Number of Years it took Engineering Students to Graduate from YSU since 2005

Figure 20a shows that engineering was the highest degree earned in the 4-year graduation for majority students represented by 83%. Similarly, Figure 20b shows that engineering was the highest degree earned in the 4-year graduation period for minority students represented by 96%. However, 20b shows when minority students leave engineering they switch to non-STEM.



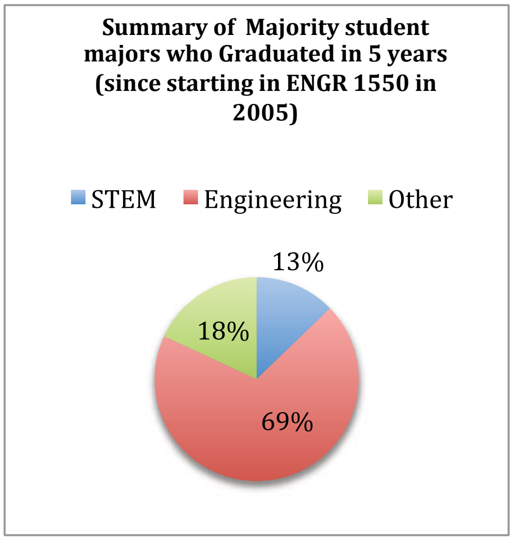
Total number of students 181
20a.



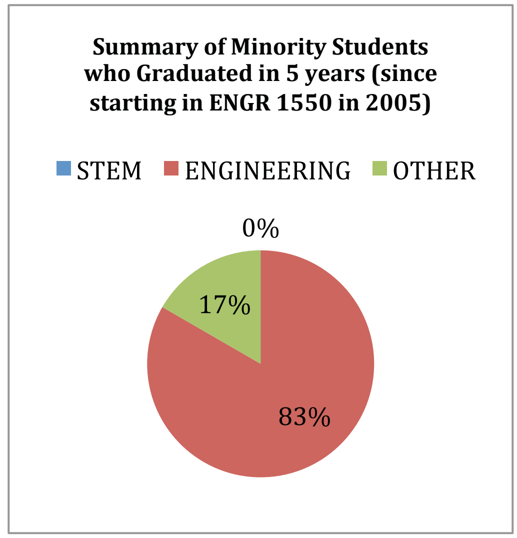
Total number of students 23
20b.

Figure 20. a and b Summary of Majority and Minority Students majors who Graduated in 4 years (since starting in ENGR 1550 in 2005)

Figure 21a shows that engineering was highest degree earned in the 5-year graduation period for majority students at 69% and in 21b it shows 83% for minority students. This shows that during this graduation period, there was a lower percentage of engineering completion rates among majority engineering students.



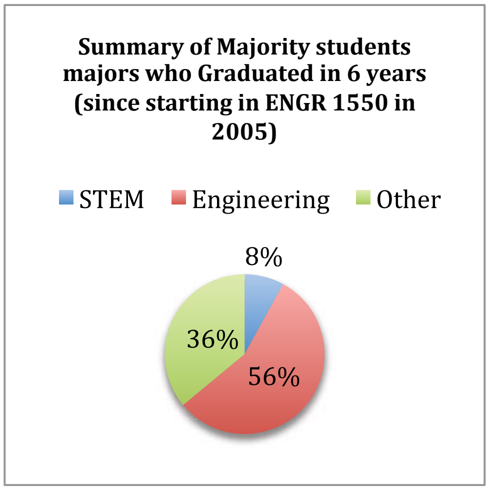
Total number of students 94
21a.



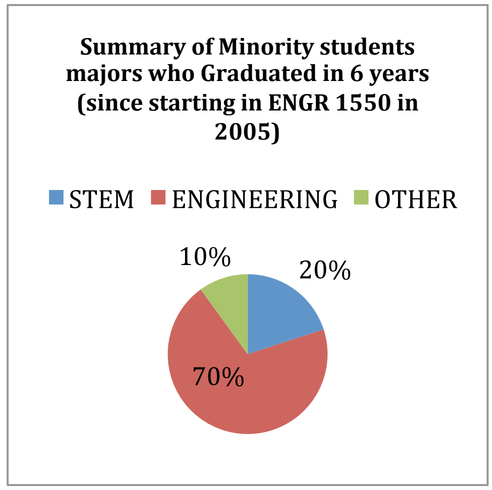
Total number of students 12
21b.

Figure 21. a and b Summary of Majority and Minority Students who Graduated in 5 years (since starting in ENGR 1550 in 2005)

Figure 22a shows that of all the students that initially took ENGR 1550 between 2005 and2012 and graduated in 6 years. Most were students who remained in engineering (56%); however, other (non-STEM) was the second highest degree with 36%. Figure 22b shows that among minority students, engineering was the highest degree earned in the 6-year graduation with 70%, and STEM was the second highest degree with 20%.



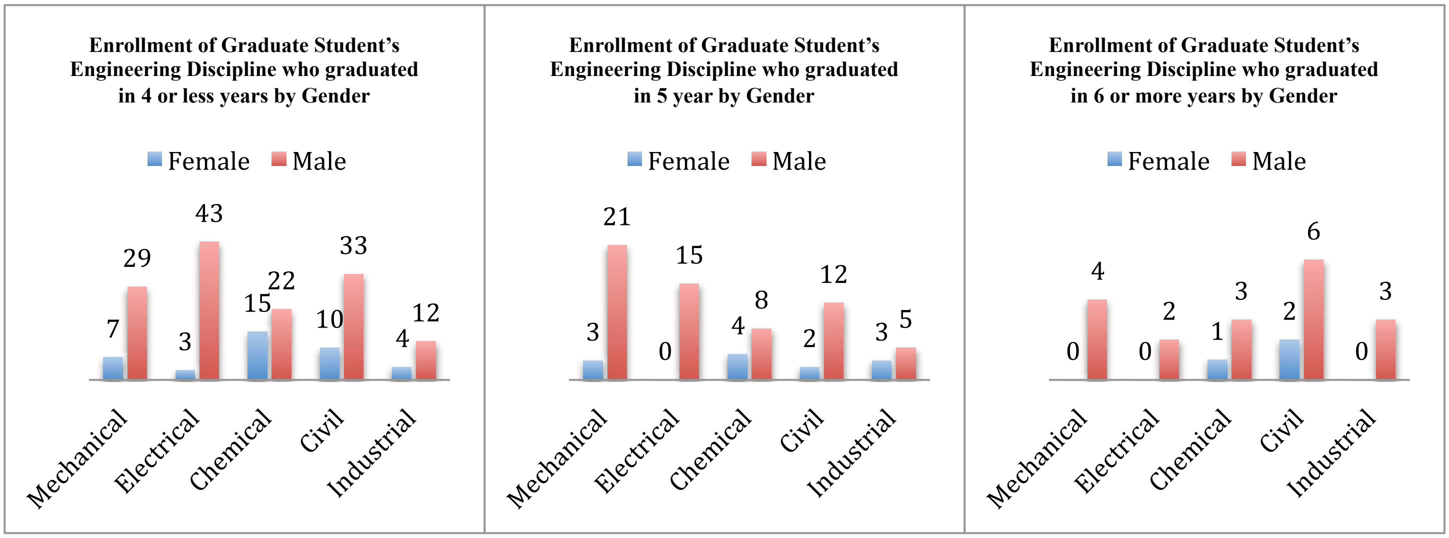
Total number of students 22
22a.



Total number of students 10
22.b

Figure 22. a and b Summary of Majority and Minority Students Majors who Graduated in 6 years (since starting in ENGR 1550 in 2005)

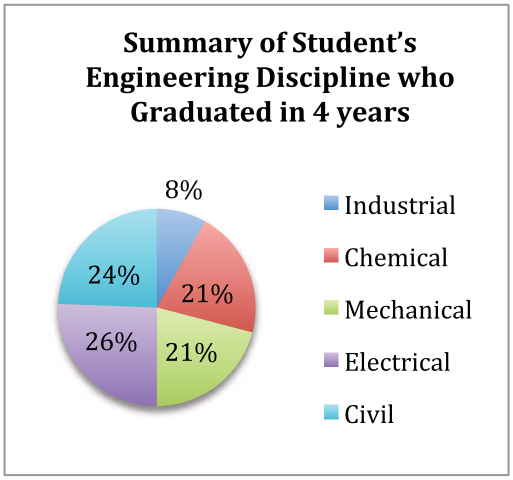
Figure 23a shows that students who graduated in 4 or less years. Electrical engineering had the highest number of graduates with 46 students while Civil engineering had second highest with 43 students. Figure 23b shows that students who graduated in the 5 years Mechanical Engineering had the highest enrollment with 24 students. Electrical Engineering had second highest with 15 students. Figure 23c shows that students who graduated in 6 or more years with Civil Engineering having the highest enrolled with 8 students.



23a. 23b. 23c.

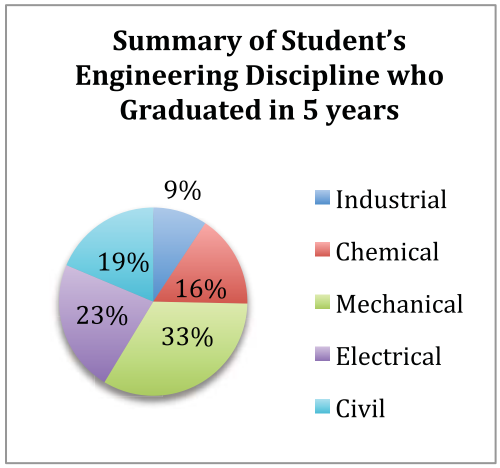
Figure 23. a-c Enrollment of Graduate Student's Engineering Discipline who graduated in 4,5 and 6 years by Gender

Figure 24 a-c shows a summary of students in engineering discipline who graduated in 4, 5 and 6 years. Figure 24a shows 4 year electrical engineering graduates had the highest graduate percentage at 26%, Civil Engineering was second highest at 24%, and a tie between Mechanical and Chemical Engineering at 21%. Figure 24b shows 5-year mechanical engineering students had the highest graduate percentage at 33%, and second highest was Electrical Engineering at 23%. Figure 24c shows 6-year engineering Civil Engineering had the highest graduate percentage at 33% while the second highest was Mechanical Engineering at 28%. Over the graduation period, students who took longer to graduate included those majoring in Industrial and Chemical Engineering. Compared with enrollment in Figure 23a, Electrical and Civil Engineering had the highest number of incoming students, which verifies the high percentage in graduation in Figure 24a. In Figure 23bMechanical and Electrical Engineering had the highest number of incoming students while figure 24b verifies the high percentage in graduation. In Figure 23c Civil Engineering had the highest number of incoming students compared to other engineering majors. As a result, in figure 24c Civil Engineering students had the highest graduation rate among students who completed their degree in 6 or more years.



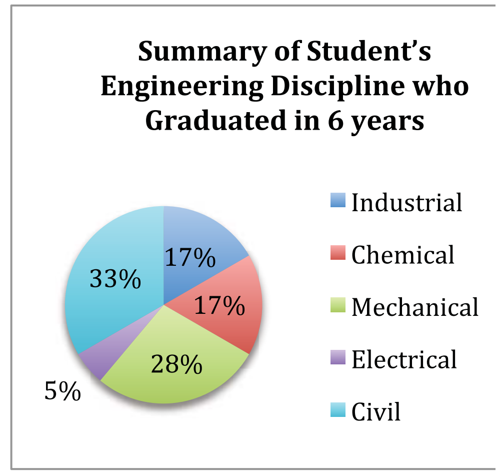
Total number of students 172

24a.



Total number of students 75

24b.



Total number of students 18

24c.

Figure 24. a-c Summary of Student's Engineering Discipline who Graduated in 4,5 and 6 year

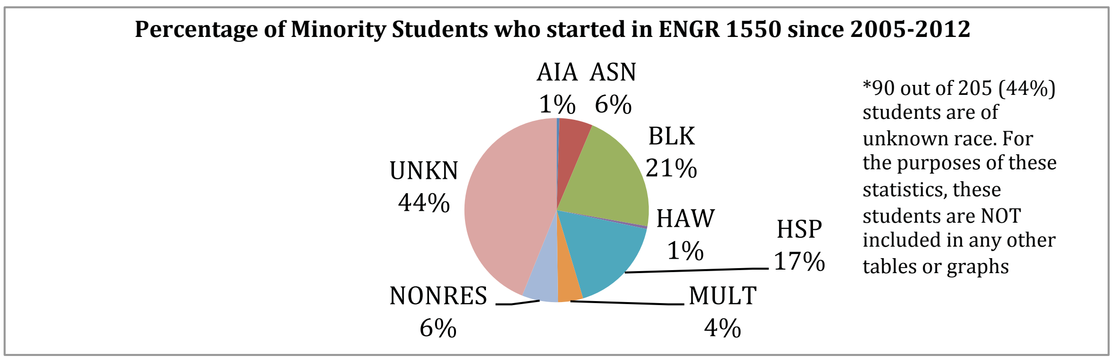
Table 7 shows the significant difference in time taken to graduate in the engineering discipline. Based on the 95% confidence interval and p-value we conclude that there were significant differences between Electrical Engineering and all engineering disciplines. Electrical Engineering had the shortest duration to graduation time compared to other engineering disciplines. Industrial Engineering took the longest duration for students to graduate at 4.33 years relative to all engineering students

Table 7. T-Test Results for Graduation time by Engineering Discipline

Engineering Major	Graduation Time	T-Value	P-Value	Significance
Chemical	4.22 years	0.30	0.764	Not Significance
Civil	4.28 years	0.75	0.458	Not Significance
Electrical	**3.99 years**	**-2.25**	**0.026**	**Very Significance**
Industrial	4.33 years	0.90	0.376	Not Significance
Mechanical	4.19 years	0.130	0.900	Not Significance

4.3 ANALYSIS OF MINORITY DATA

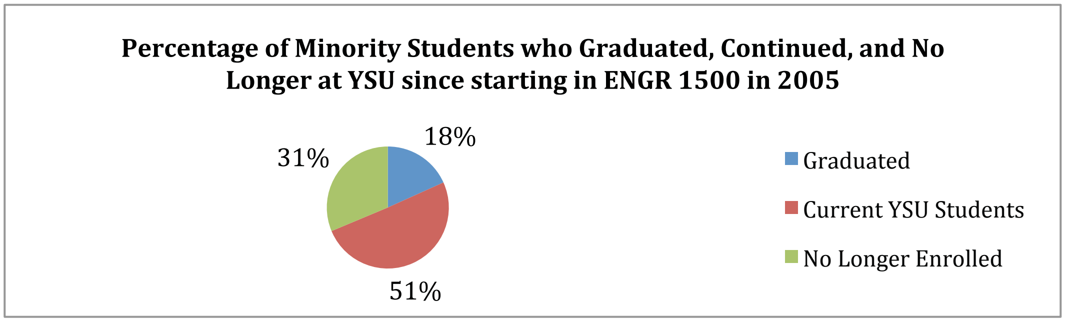
Figure 25 shows the total number of minority students who took ENGR 1550 by race. The highest at 21% of the students were African American.



Total number of students 205

Figure 25. Percentage of Minority Students Race who started in ENGR 1550 since 2005-2012

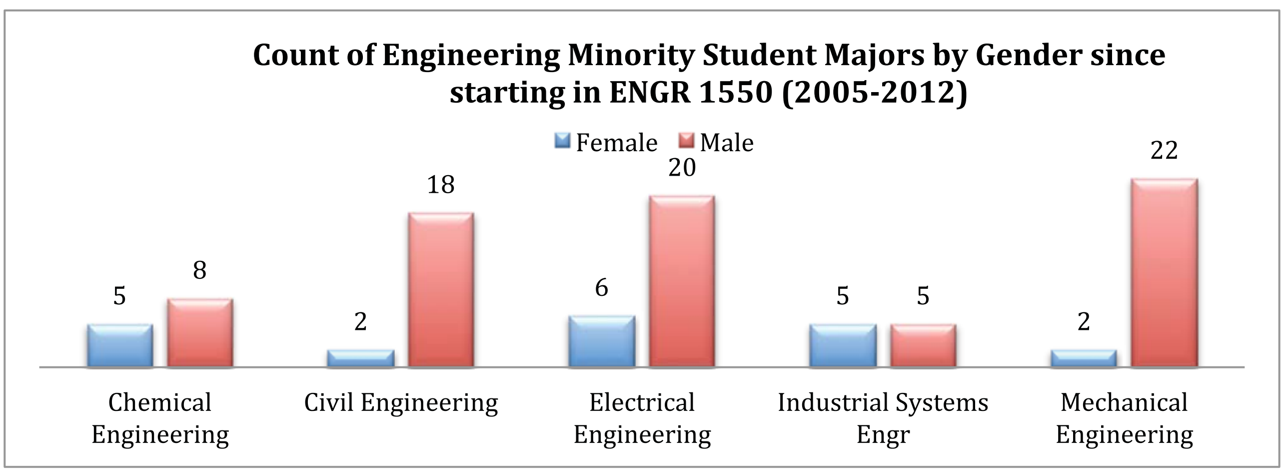
Figure 26 shows the percentage of continuing, graduated, and dropped minority students since enrolling in ENGR 1550. Continuing students had the largest percentage at 51%; however, 31% are no longer in YSU. Compared with majority students, the percentages of continuing students at YSU was lower with 46% and 20% respectively; however, the graduated percentage was about 33%, which was greater than graduated minority percentage.



Total number of students 115

Figure 26. Percentage of Minority Students who Graduated, Continued, and No Longer at YSU since starting in ENGR 1500 in 2005

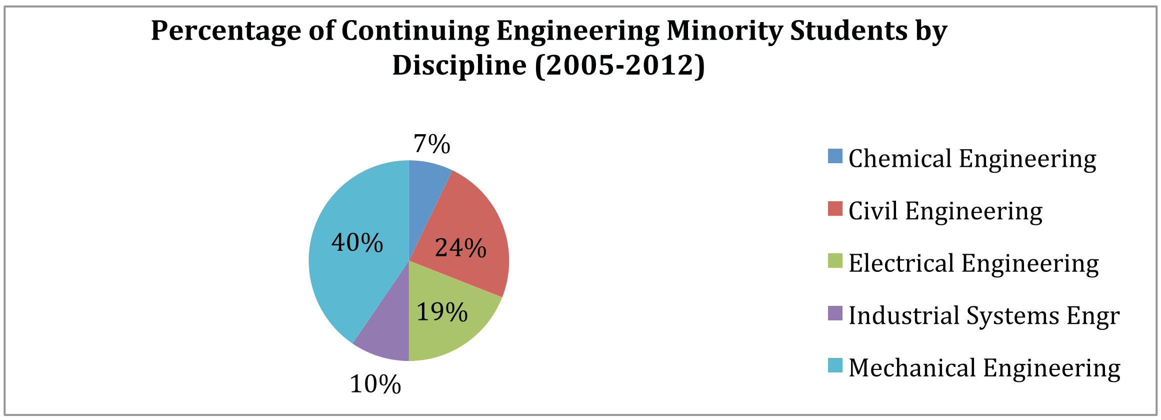
Figure 27 shows the count of male and female minority students in each engineering discipline from 2005-2012. Electrical Engineering was highest with 26 and second highest in Mechanical Engineering with 24. Comparing with majority data, there are similar characteristics in terms gender in the engineering discipline. On the other hand, continuing students had the highest in the two majors are Electrical and Mechanical Engineering with 121 and 171 respectively.



Total number of students equals 93

Figure 27. Count of Engineering Minority Student Majors by Gender since starting in ENGR 1550 (2005-2012)

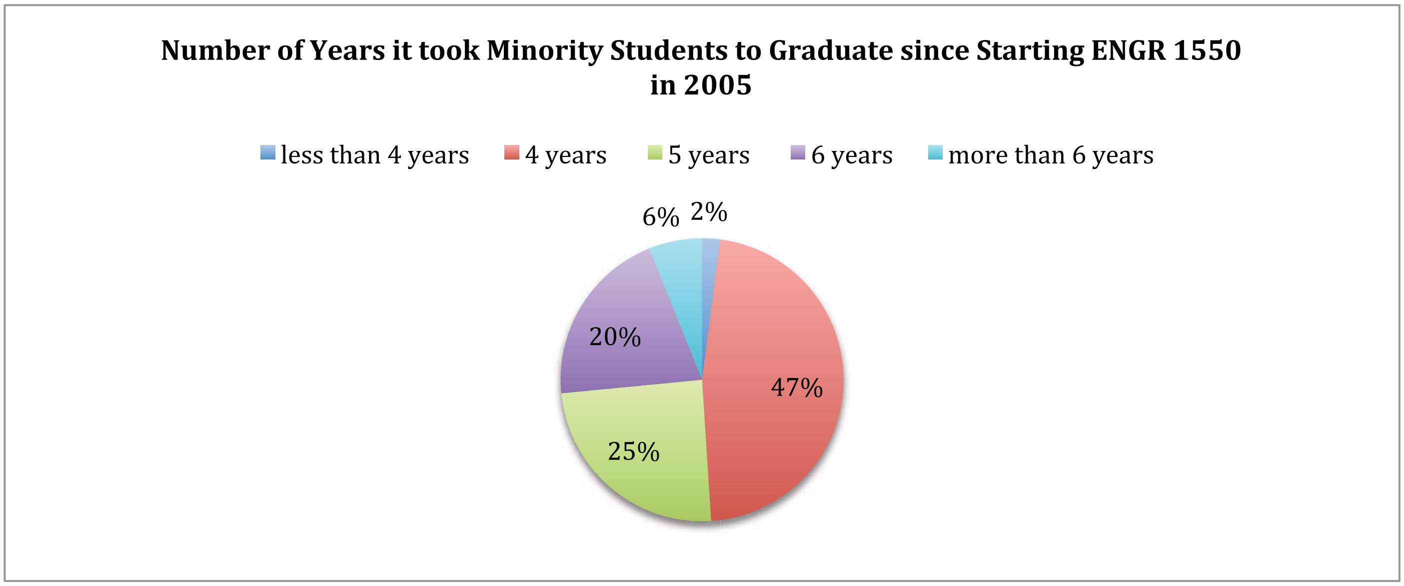
Figure 28 shows the percentages of continuing minority students towards an engineering degree. Of the 42 students who started ENGR 1550 since 2005, it shows that 40% were in Mechanical, 24% Civil, 19% Electrical, 10% Industrial, and 7% Chemical Engineering. Based on enrollment discussed previously in Figure 16, it is evident that Mechanical Engineering had the highest incoming students at 14 compared to other engineering majors



Total number of students 42

Figure 28. Percentage of Continuing Engineering Minority Students by Discipline (2005-2012)

Figure 29 shows the number of years it took for minority students to graduate. Of the 49 minority students that graduated, 49% graduated in 4 years or less, 25% graduated in 5 years, and 26% graduated in 6 or more. The average time for a minority student to graduate was 4.73 years.



Total number of students 49

Figure 29. Number of Years it took Minority Students to Graduate since Starting ENGR 1550 in 2005

A t-test was conducted to test the statistical significant of majority and minority graduation rates. Based on the 95% confidence interval, the p-value of 0.1859 was considered not significant. Thus, there is no significant difference between majority and minority graduation rate. However there is a statistical significant difference between majority and minority graduation time based on the 95% confidence interval the p-value of 0.006.

4.4 REGRESSION ANALYSIS

This analysis of the first model where engineering discipline is the dependent variable plus gender, race, ENGR 1550, First semester GPA, and Calculus 1 grades as independent variables.

Starting with Mechanical Engineering, the regression analysis was conducted to understand if there is any significance between independent variables affecting students continuing to major.

The regression equation is:

Mechanical Engineering = 0.597 - 0.0011 GENDER + 0.0146 RACE - 0.0236 Engr 1550- 0.0729 First Semester GPA + 0.0025 Calculus 1 Grade

Based on 95% confidence interval, we can conclude that the most significant factors effecting Mechanical Engineering students' probability of continuing in this major is first semester GPA because the p value was less than 0.05.

Table 8. Regression Results for Modeling Mechanical Engineering Success

Predictor	P Value	1-P value	Significance
Gender	0.982	0.018	Not Significant
Race	0.438	0.562	Not Significant
ENGR 1550 Grade	0.384	0.616	Not Significant
First Semester GPA	**0.006**	**0.994**	**Significant**
Calculus 1 Grade	0.811	0.189	Not Significant

*Null Hypothesis assume that Gender, Race, ENGR 1550 grade, First Semester GPA, Calculus Grade have no statistically significant effect on continuing in mechanical engineering

Second, based on the 95% confidence interval we can conclude that the most significant factors affecting Electrical Engineering students' probability of continuing in this major is ENGR 1550, First semester GPA and Calculus I grade because the p value was less than 0.05.

The regression equation is

Electrical Engineer = - 0.193 + 0.0003 GENDER + 0.0178 RACE + 0.0794 Engr 1550 - 0.0760 First Semester GPA + 0.0381 Calculus 1 Grade

Table 9. Regression Results for Modeling Electrical Engineering Success

Predictor	P Value	1- P value	Significance
Gender	0.995	0.005	Not Significant
Race	0.241	0.759	Not Significant
ENGR 1550 Grade	**0.000**	**1.000**	**Significant**
First Semester GPA	**0.000**	**1.000**	**Significant**
Calculus 1 Grade	**0.000**	**1.000**	**Significant**

*Null Hypothesis assume that Gender, Race, ENGR 1550 grade, First Semester GPA, Calculus Grade have no statistically significant effect on continuing in electrical engineering

Thirdly based on 95% confidence interval we can conclude that the most significant factors effecting Civil Engineering students' probability of continuing in this major are first semester GPA and Calculus grade because the p value was less than 0.05.

The regression equation is

Civil Engineering = - 0.177 - 0.0290 GENDER - 0.0089 RACE - 0.0270 Engr 1550 + 0.0777 First Semester GPA + 0.0363 Calculus 1 Grade

Based on the 95% the most significant factor is first semester GPA, calculus grade

Table 10. Regression Results for Modeling Civil Engineering Success

Predictor	P Value	1- P value	Significance
Gender	0.376	0.624	Not Significant
Race	0.462	0.538	Not Significant
ENGR 1550 Grade	0.122	0.878	Not Significant
First Semester GPA	**0.000**	**1.000**	**Significant**
Calculus 1 Grade	**0.000**	**1.000**	**Significant**

*Null Hypothesis assume that Gender, Race, ENGR 1550 grade, First Semester GPA, Calculus Grade have no statistically significant effect on continuing in Civil engineering

Fourthly, based on 95% confidence interval we can conclude that the most significant factors effecting Chemical Engineering students' probability of continuing in this major is first semester GPA and calculus grade because the p value is less than 0.05.

The regression equation is

Chemical Engineering = - 0.0991 - 0.0502 GENDER - 0.0089 RACE - 0.0099 Engr 1550+ 0.0273 First Semester GPA + 0.0376 Calculus 1 Grade

Table 11. Regression Results for Modeling Chemical Engineering Success

Predictor	P Value	1- P value	Significance
Gender	0.111	0.889	Not Significant
Race	0.444	0.556	Not Significant
ENGR 1550 Grade	0.554	0.446	Not Significant
First Semester GPA	**0.093**	**.907**	**Significant**
Calculus 1 Grade	**0.000**	**1.000**	**Significant**

*Null Hypothesis assume that Gender, Race, ENGR 1550 grade, First Semester GPA, Calculus Grade have no statistically significant effect on continuing in chemical engineering

Finally, based on 95% confidence interval we can conclude that the most significant factors effecting Industrial Engineering students in continuing in this major is ENGR 1550 grade and first semester GPA grade because the p value was less than 0.05.

The regression equation is

Industrial Engineering = 0.0112 + 0.0156 GENDER - 0.0014 RACE + 0.0323 Engr 1550- 0.0384 First Semester GPA + 0.00204 Calculus 1 Grade

Table 12. Regression Results for Modeling Industrial Engineering Success

Predictor	P Value	1- P value	Significance
Gender	0.578	0.422	Not Significant
Race	0.895	0.105	Not Significant
ENGR 1550 Grade	**0.031**	**0.969**	**Significant**
First Semester GPA	**0.008**	**0.992**	**Significant**
Calculus 1 Grade	0.722	0.278	Not Significant

*Null Hypothesis assume that Gender, Race, ENGR 1550 grade, First Semester GPA, Calculus Grade have no significant statistically effect on continuing in industrial engineering

Analysis of second model where graduation time was the dependent variable while the first year GPA, gender, race, Calculus I and ENGR 1550 grade were independent variables. Based on the dependent variable the objective was to test the independent variables for statistically significant differences.

The regression equation is

Graduation time = 5.54 + 0.010 Gender + 0.130 Race - 0.162 ENGR 1550 Grade - 0.111 First Semester GPA - 0.0290 Calculus Grade

Based on a 95% confidence interval we can conclude that race was the most significant factor because $p>0.05$. Race has a positive effect based on the positive coefficient. Therefore, it can be concluded that race doesn't affect persistence in engineering discipline but it affects graduation time

Table 13. Regression Results for Modeling Gradation time

Predictor	P Value	1-P-value	Significance
Gender	0.930	0.070	Not Significant
Race	**0.011**	**0.989**	**Significant**
ENGR 1550 Grade	0.122	0.878	Not Significant
First Semester GPA	0.173	0.827	Not Significant
Calculus I Grade	0.345	0.655	Not Significant

*Null Hypothesis assume that Gender, Race, ENGR 1550 grade, First Semester GPA, Calculus Grade have no statistically significant effect on graduation time

5.0 CONCLUSION AND RECOMMENDATIONS

This chapter will compile the content of all the other chapters to give a clear picture of the discussions. It also makes recommendations to address the issue of retention rates in first-year engineering programs at YSU.

5.1 CONCLUSION

The conclusion from this research related to student persistence is summarized with the research question statements:

1. Is race/ethnicity a statistically significant factor in engineering persistence from year to year and retention to graduation in engineering?

Based on the regression analysis, it was found that race/ethnicity was not statistically significant factor for continuing in engineering. However, race was a significant factor on time to graduation with a positive effect. It should be noted, that the number of non-white students, represented by 17% between 2005 and 2012, was much smaller than majority / white students. As such, all minority students were combined for analysis purposes. In this regard, future work should attempt to improve understanding on the relative performance of each race / ethnicity tracked by the university.

2. Is gender a statistically significant factor in engineering persistence from year to year and retention to graduation in engineering?

Based on the regression analysis gender was not a statistically significant factor according to the 95% confidence interval in retention to graduation and persistence year to year. A t-test was conducted to test the statistical significance of gender in engineering success.

Based on the 95% confidence interval there was a statistical significance between:

- ❖ Male to female retention rate (female had a higher retention rate then male)
- ❖ Male to female gradation rate (male graduated at a shorter time than female)

Because ratios were higher, there were more female engineers retained to graduation since taking ENGR 1550 than males. In addition male engineering students took shorter time to graduate than female. On average it takes 4.39 years for females to graduate compared to 4.28 years for males. Prior studies found that pre-college math and science performance were statistically significant factors when predicting retention, and should be considered in future work (Veenstra, 2008). More analysis needs to be performed to establish if females are better prepared in entering engineering and establish how to increase female student enrollment and retaining in engineering and STEM majors.

3. What are the graduation rates of (4, 5, and 6 year) by engineering program and are differences statistically significant?

   Graduation rates by engineering majors were as follows:

   - ❖ Mechanical Engineering 4.19 years
   - ❖ Chemical Engineering 4.22 years
   - ❖ Civil Engineering 4.28 years
   - ❖ Electrical Engineering 3.99 years
   - ❖ Industrial Engineering 4.33 years

Based on the 95% confidence interval there was statistical significant difference between Electrical Engineering graduation time and overall graduation time. The analysis of 4, 5, and 6 year graduation periods (time taken to graduate), engineering was a dominant major for all three segments. However, it was evident that the trend between majority and minority students suggests that the longer a student stayed to graduate, the engineering percentage decreased meaning the student was more likely to have changed majors either to STEM or other non-STEM majors. Further analysis needs to be done to understand why electrical engineering has the lowest graduation time compared to other engineering majors. Are electrical engineers better prepared in pre-college math and science compared to other engineering majors?

4. What are the retention rates by engineering program and are differences statistically significant?

Chemical and Civil engineering had the highest yearly retention students at 52%. Industrial Engineering had 43%, Electrical Engineering had 39% and Mechanical engineering had 30% retained from year to year. Based on the 95% confidence interval, there was no statistical significance between Chemical, Civil, Electrical and Industrial Engineering. However, there was a statistical significance difference in Mechanical Engineering where students taking mechanical engineering after ENGR 1550 had the highest enrollment among other engineering majors.

5.2 RECOMMENDATIONS

i. Recommendation Attributed to Future Studies

Recommendation 1: The current predictive model did not effectively take into account qualitative issues that may have influenced the observed outcomes. Thus, future studies need to address qualitative variables, such as, using nominal variables to determine whether the individual belongs to a certain category (e.g. gender), using ordinal variables to determine social-economic status, using preference variables, specific discrete variables (e.g. survey) and, multiple response variables in the predictive model.

ii. Recommendation Attributed to Best Course & Collaboration

Recommendation 2: The Engineering 1550 course was a significant factor for two engineering disciplines: Industrial and Electrical engineering. These continued to have high retention. It is recommended that a program be implemented to further study the effectiveness of enrollment in Engineering 1550 for students who need a high level of advising. In addition, it is recommended that an upper level career development course be considered.

iii. Recommendation Attributed to Calculus or Pre-calculus

Recommendation 3: Even though there may be several areas requiring special attention, calculus was selected as a critical area for students to continue in Electrical, Civil, and Chemical engineering. More attention should be given through adequate consideration of students' mathematics skill levels before admission to an engineering program. Some support programs should help develop efficiency in supporting a higher self-rating of student's math ability.

5.3 TRACKING CHANGES

In order to assess the presence of improvement in the program, the changes suggested can be tracked at the end of every term to establish the presence of improvements being made by each engineering department. This will entail tracking gender, race/ethnicity, start of advisement, and engineering discipline that a student enrolled. This can be implemented on an ongoing basis in order to adequately track progress, allow for modifications, and assessment on the efficacy of the adopted strategies.

BIBLIOGRAPHY

ACT (2006). *ACT Policy Report: Developing the STEM Education Pipeline,* Retrieved 5/12/07 from http://www.act.org/path/policy/pdf/ACT_STEM_PolicyRpt.pdf.

Adelman, C. (1998). *Women and Men of the Engineering Path: A Model for Analyses of Undergraduate Careers,* U.S. Department of Education.

Astin, A.W. and Astin H. (1992). Undergraduate Science Education: The Impact of Different College Environments on the Educational Pipeline in the Sciences". [Electronic Version] (ERIC Document Reproduction Service No. 362404). Retrieved 2/26/05 from www.eric.ed.gov.

Braxton, J.M. (ed). (2000). *Reworking the Student Departure Puzzle,* Nashville: Vanderbilt University Press.

Cough, G. W. (2006). Editor's Note: Reforming Engineering Education [Electronic Version]. *The Bridge, Linking Engineering and Society*, 36 (2) Washington D.C.: National Academy of Engineering.

Dean, M.L., Evanecky, D.J., Hartr, N.W., Phillips, J.A. Summers, M.L., (2004). Systems Thinking: Theory Anchored in the Real World. *Proceedings of the 2004 ASEE Annual Conference and Exposition*, ASEE.

Deming, W.E, (1994). *The New Economics for Industry*, Government, Education, MIT.

Dew, J., (2007, April). Quality Goes to College. *Quality Progress,* 45-52, American Society for Quality.

Dey, E.L., (2007). Strategic Perspectives on Advancing Knowledge. Presentation at the 2007 CSHPE National Conference, Ann Arbor. March 24. 2007. viewed at http://esmane.physics.lsa.umich.edu/wlap-cwis/browser.php?ResourceId=696

Freidman, T. L. (2006). *The World is Flat: A Brief History of the Twenty-First Century,(updated)* New York: Farrar, Straus and Giroux.

Grose, T. K. (2006, October). Trouble on the Horizon. *ASEE Prism*, 26-31.

Hacker, D. (2005, November). Employment Outlook 2004-14: Occupational Employment Projections to 2014 [Electronic Version], *Monthly Labor Review*, 70-101, U.S. Bureau of Labor Statistics

Morrison, A. K. (2007). *Free school teaching: A journey into radical progressive education*. New York. Suny Press.

National Academy of Engineering (NAE).(2004). *The Engineer of 2020: Visions of Engineering in the New Century,* Washington DC: The National Academies Press.

National Academy of Sciences (NAS), Committee on Science, Engineering, and Public

Policy (COSEPUP). (2005). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, Washington DC: The National Academies Press. Retrieved 05/08/07 from http://www.nap.edu/catalog/11463/html

National Center for Public Policy and Higher Education (NCPPHE). (2005). *Policy Alert: Income of U.S. Workforce Projected to Decline if Education Doesn't Improve*,Retrieved 5/14/07 from http://www.highereducation.org/reports/pa_deline/pa_decline.pdf.

National Science Board (NSB). 2004. *Science and Engineering Indicators.* Retrieved May 9, 2007 from http://www.nsf.gov/statistics/seind04/

NSB. (2006). *Science and Engineering Indicators.* Retrieved May 9, 2007 from http://www.nsf.gov/statistics/seind06/

NSB. (2007). *The Science and Engineering Workforce: Realizing America's Potential,* Retrieved 5/12/2007 from http://www.nsf.gov/nsb/documents/2003/nsb0369/start.htm

Tinto, V. (1993). *Leaving College: Rethinking the Causes and Cures of Student Attrition*,(2nd *ed.)* Chicago: The University of Chicago Press.

Tinto, V. (2006). Research and Practice of Student Retention: What Next? *Journal of College Student Retention,* 8(1) 1-19.

Tribus, M., (n.d.) “TQM in Education, The Theory and How to Put it to Work”. Retrieved from http://deming.ces.clemson.edu/pub/den/theory_qinedu.pdf

Tribus, M. (n.d). *The transformation of American education to a system for continuously improved learning.* Hayward, CA: Exergy Inc. Retrieved from http://www.exergy.se/goran/hig/ses/pdfs/transameredu.pdf

Veenstra, C.P. and Herrin, G.D. (2006b). An Analysis of Graduation Rates at Research Universities, *2006 ASEE World Conference Proceedings*, 2006-760.

Veenstra, P.C. (2008). *Modeling freshman engineering success*. New York: Proquest.

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October 24, 2012

Dr. Kerry Meyers, Principal Investigator
Department of Mechanical & Industrial Engineering
UNIVERSITY

RE: HSRC Protocol Number: 037-2013
Title: Do First-year Orientation Courses Alter Students' Plans for Engineering Study?

Dear Dr. Meyers:

The Institutional Review Board has reviewed the abovementioned protocol and determined that it is exempt from full committee review based on a DHHS Category 5 exemption. Please note that ethical standards dictate that you avoid presenting direct quotes from student responses that are potentially identifying when you present your project.

Any changes in your research activity should be promptly reported to the Institutional Review Board and may not be initiated without IRB approval except where necessary to eliminate hazard to human subjects. Any unanticipated problems involving risks to subjects should also be promptly reported to the IRB.

The IRB would like to extend its best wishes to you in the conduct of this study.

Sincerely,

Peter J. Kasvinsky
Dean, School of Graduate Studies and Research
Research Compliance Officer

PJK/cc

c: Dr. Hazel Marie, Chair
Department of Mechanical & Industrial Engineering