The Pennsylvania State University

The Graduate School

College of Education

MONEY, MATH AND ENGINEERING: THE RELATIONSHIPS BETWEEN COMMUNITY ECONOMICS, MATH PREPARATION AND THE GRADUATION OF RACIALLY UNDERREPRESENTED ENGINEERS

A Dissertation in

Workforce Education and Development

by

Amy Louise Freeman

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Doctor of Philosophy

August 2009

The dissertation of Amy Freeman was reviewed and approved* by the following:

William J. Rothwell
Professor of Education
Dissertation Advisor
Chair of Committee

Judith A. Kolb
Associate Professor of Education
Professor in Charge of Graduate Programs in Workforce Education and Development

Edgar P. Yoder
Professor of Agricultural and Extension Education

Kenneth Gray
Professor Emeritus of Education

*Signatures are on file in the Graduate School.

ABSTRACT

A primary gateway to a career in engineering is the attainment of the bachelor of science degree in engineering. In contrast, a common barrier to becoming an engineer is failure to attain the degree. Those variables that are related to college graduation are often in place prior to college admission. The purpose of this study was to examine the relationship of four independent variables that were in place after high school graduation for African American and Hispanic American engineering students *(N=504)*, and the correlation of these variables with college graduation outcomes five years later. These factors included Scholastic Aptitude Test (SAT) math scores, calculus preparation level as identified through the Penn State First-Year Testing, Counseling and Advising Program (FTCAP) score, high school grade point average (GPA), and the community economic index (CEI) which indicated the percentage of students qualifying for free or reduced cost lunch at a given student's high school. Three college graduation outcomes were defined as: engineering graduate, other graduate and non-graduate. It was determined that the high school CEI was negatively correlated with math preparation. Math preparation was positively correlated with the likelihood of graduation in engineering. Non-graduation (as compared to graduation in engineering) is positively correlated with the CEI, although the CEI is not significantly correlated with high school GPA. A multinomial logistic regression showed that the combined effect of the GPA, FTCAP, SAT and CEI does explain 75.6% of the variance in graduation outcome.

In summary, access and admission for all engineering college students is determined by pre-college math preparation. High school math preparation is determined

by the degree of funding available to high schools which, in turn, is affected by the local tax base or income level of local residents (partially indicated through the CEI). This would suggest that engineering access is not only a result of social and academic conditions, but also of economic conditions that could conceivably have a tangible economic solution.

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

ACKNOWLEDGEMENTS

I wish to thank my parents, Laverne Pickett Freeman and Charles Albert Freeman for their continued support of my educational endeavors and their active interest in all my undertakings. I am continually amazed at the fact that they successfully raised eight productive citizens of the world at a time when it was especially difficult for African Americans in this country to have access to many of the opportunities we enjoy today. Through all of this, they planted the seeds that have since yielded eight high school diplomas, seven bachelor's degrees, seven master's degrees and now, the first doctorate in the collection. I can only hope to influence the world in such a magnificent way.

I am also appreciative of all my brothers and sisters, both biological and otherwise. Many of you kept me laughing and looking forward. I am especially indebted to Wendy Freeman-Campbell whom I have spoken with almost everyday for many years now. Although she informed me that she never reads acknowledgements in scholarly works, she is partly responsible for the completion of this one because she has inspired me to continue when I would have stopped many, many a day. She helped me to transform the most mundane of tasks into the most uplifting parts of the journey.

My daughter and son, Camerson and Theran are the underlying reason for all that I do. They and my husband John Thomas Cripe have sacrificed for four and a half years, taking up the slack without complaint so that I could complete this milestone. I appreciate the life long commitment of you all.

The staff of the Office of Engineering Diversity has inspired me to complete this work by reminding me every day of the importance of the work we do to assist thousands of students who have honored us with their presence over the years. Their first words upon meeting us are always the same, “I want to be an engineer.” And they trust us to provide the tools they need to get there.

As dissertation committees go, I have had the best! Thank you Drs. Rothwell, Kolb, Yoder and Gray for being so easy to work with, making this educational experience one of the most enjoyable I have ever had.

Chapter 1

INTRODUCTION

Overview

In 2007, African American and Hispanic engineers composed 25.0% of the total workforce in the United States (U.S. Department of Labor, 2007). Were this figure evenly distributed across all occupations, one in four of all employed persons in the U.S. (waiters, landscapers, doctors, and others) would be African American or Hispanic. However, this is not the case for the engineering profession where African American and Hispanic Americans compose only 11.7% of engineering occupations (approximately 1 in 10). Many factors contribute to the underrepresentation of these populations in technological fields. One primary variable determining access to the engineering profession is the attainment of the bachelor of science degree in engineering. Over the past 30 years, successful remedies have typically included race-based college admission selection processes and math-intensive college retention programming. The result has increased enrollments, but also raised legal questions regarding racial preferences. As additional non-racial barriers are identified and removed, a more equitable number of underrepresented students may attain access to the engineering profession. Access for all engineering college students is determined by pre-college math preparation. High school math preparation is determined by the degree of funding available to high schools which, in turn, is affected by the local tax base or income level of local residents. This would suggest that engineering access is not only a result of social and academic conditions, but also of economic conditions that could conceivably have a tangible economic solution.

The next section contains a review of historical perspectives regarding underrepresented students' access to engineering; problems associated with current remedies; and the significance of identifying economic factors that determine technological career paths.

Historical Perspectives

A primary gateway to a career in engineering is the attainment of the bachelor of science degree in engineering. A common barrier to becoming an engineer is failure to attain the degree (Maton, Hrabowski & Schmitt, 2000). Reasons for this disconnect include socialization, lack of high school math preparation, educational funding problems, low self confidence levels and inadequate college retention programming strategies (Jablin, 2000; Kezar, 2000; Taylor & Miller, 2002). Studies conclude that the low retention numbers are more likely to be a symptom of long-term racism in U.S. employment practices than a core problem (Wilson, 1997). Another factor is the economic inadequacies in the public education system that systematically leave the majority of this particular group unprepared for careers in engineering and sciences (The Education Trust, 2003; Thomas, 2000).

Common interventions, or remedies designed to halt attrition and retain those starting the degree in the first year, typically involve racially targeted selection processes for admission and retention services during college. The most common of these are the Minority (or Multicultural) Engineering Programs (MEP), a concept that began in the 1970s following the Civil Rights Era (Good, 2000; Roach, 2006). A MEP is a group of university-based services that focus on recruiting underrepresented students to engineering, reducing the dropout rate and increasing the graduation rate. As of 2008, more than 75 engineering universities have created MEP services designed to address this problem, raising the need for a national network of MEP providers (National Association of Multicultural Engineering Program Advocates, 2008). Those institutions that are most successful in recruiting and graduating racially underrepresented engineers have MEP services in place (Morrison & Williams, 1993). The MEP director is presented with the task of increasing the numbers of underrepresented engineering employees in the industry. Interventions take the form of programming designed by MEP directors at the university level to assist new engineers in understanding the components of a successful academic experience and professional working relationship (Landis, 1985; Roach, 2006). Typical retention methods utilized by MEPs are further detailed in chapter 2 of this dissertation. Despite successes in this area over the past two decades, graduation rates still remain low at 38% for underrepresented students compared to 63% for majority students (Commission on Professionals in Science and Technology, 2008). Contributing factors include other unresolved social problems such as high school math preparation and a lack of economic resources available to students before entering college. These factors extend outside of the university and corporate forums, yet are primary factors in determining the success of students entering these environments.

The legal ramifications of race-based access to college admissions, retention services and resources has been reflected in several court cases (*Regents of the University of California v. Bakke*, 438 U.S. 265, 1978; *Gratz v. Bollinger*, 539 U.S. 244, 2003; *Hopwood v. Texas*, 78 F.3d 932, 1996) and anti-affirmative action propositions in the states of California, Washington, and Texas, with others considering this alternative

(Proposition 209, 1996). In light of these cases Somers (2000) suggested that student selection and retention design should be based on those non-racial factors that affect specific racial groups in specific ways. For example, the elements affecting persistence in African Americans are not the same as those factors affecting White students. A few of these elements include student motivation, aspirations, class level, on-campus living, and full time attendance. The purpose is to enable a retention program to withstand potential legal scrutiny should discriminatory accusations arise. Similarly, Fisher (2000) focused on a selection process involving those non-racial elements shown to predict high achievement in African American students which may not apply to majority students. These would include the students' self concept of their own academic abilities, the students' perceptions of the opportunity for success in college, and social support from parents, teachers, and peers.

The graduation rate for underrepresented engineering students depends upon several variables, many of which are personal to the student and difficult to measure and consistently interpret. The purpose of this dissertation was to examine tangible, economically related variables that can be correlated with the graduation of those starting in the engineering major. This dissertation evaluated the relationship of four tangible independent variables that were in place at the time of the high school graduation for actual engineering college graduates five years later. These factors included:

1. Scholastic Aptitude Test (SAT) scores
2. Calculus preparation level identified through the Penn State First-Year Testing, Counseling and Advising Program (FTCAP). After the testing portion of this process, each student receives a math FTCAP score.

3. Community economic index (CEI) showing the poverty level of the public high school community, indicated through the percentage of students qualifying for free or reduced lunch.
4. High school grade point average (GPA).

Each of these variables is important because they have been shown to be related to each other or student retention regardless of major. For engineering students, math preparation is the key to success. Although standardized testing (such as the SAT) has been heavily scrutinized for its racial and cross-cultural fairness, test scores are still primary tools and indicators that determine admission to technical fields. Grade Point Average (GPA) identifies the student's academic performance in comparison to peers at the same school. For underrepresented students, it is often the most accurate indicator of college success when compared to the SAT score for the same student (Fleming, 2000; Lerner & Nagai, 1997; Newton, 2007). In this study the economic status of the community in which the high school is located is indicated by the percentage of students receiving free lunch (Institute of Education Sciences, 2007). This is typically the same community in which local taxes would be collected to support public schools. The economics associated with high school funding are directly correlated with the high school's resources for qualified teachers and math programs (Lederer, 2004; Moin, 2005) and, subsequently, students' math preparation (*Campaign for Fiscal Equity v. State of New York*, 2003).

Historical evidence shows that engineering success for underrepresented students is directly associated with high school math preparation, while funding levels are associated with high school resources and college retention programming. Methods for increasing the numbers of underrepresented engineers tend to focus more on college retention programming and community building as students attempt to complete the final 5 years of the journey to becoming an engineering professional. This thesis contains an assessment of funding issues related to pre-college academic and economic conditions and their effect on post-college outcomes.

The Problem

This dissertation set out to determine the extent to which certain economic barriers may prevent African Americans, Latinos and Native Americans attending majority research institutions from becoming engineers. Economics are directly related to the level of resources available in local high schools for preparing (or failing to prepare) those wishing to enter engineering. School funding is directly associated with family income or the local tax base. When schools are under-funded, science and math programs often suffer from the lack of funding and human resources, resulting in a shortage of math teachers, critical upper-level math courses, and less funding for science laboratory equipment (*Campaign for Fiscal Equity v. State of New York*, 2003). The lack of early math and science preparation affects the competitiveness of these students with those from higher-income areas, as reflected in lower standardized test scores and sometimes GPA. The result is that those in lower-income areas are less likely to enter technical fields (Chambers, Levin, & Parish, 2006; Engstrom & Tinto, 2008).

It has been shown that occupations are determined by individual choice, perseverance and several other variables controlled by the individual (or group) seeking employment (Brazziel & Brazziel, 2001; Callanan & Benzing, 2004; Jablin, 2000;

Levine, 2006). Economic variables, however, are more readily measured and modified than intangible human factors such as self-confidence or determination, often related to the retention of engineering students in the first year. In addition, they are not race-related. Were it possible to adjust these variables by adding funding to public schools or math preparation programs, the outcome could be additional engineers of all backgrounds in the profession, with racial representation proportional to the general population.

Significance

The significance of this dissertation is that it not only identifies tangible variables that can be defined and related to graduation rates, but that these same elements could conceivably be modified in a positive way to deliberately affect outcomes, yielding more underrepresented engineers into the profession. Tangible economic variables would include high school math programs, teacher training, and college retention programs. The outcome would conceivably be an enlarged, more culturally diverse, national pool of engineers.

Current diversity issues in the U.S. regarding the inclusion of African, Hispanic and Native Americans and women in the technological workforce are based on world competition. Globally, the need for engineers in the future currently exceeds the number produced in the U.S. China produces five times more engineers at a higher education level and a lower wage than that demanded by the U.S. engineers. If the U.S. is to remain the primary holder of technological intellectual property in the world, it has two options: to create more engineers through domestic means, or to import better-educated and economical engineering workers and services (Galama & Hosek, 2007; National

Academy of Sciences, 2007). The push to enlarge the pool of engineers has driven corporations to deliberately seek those previously left out of the engineering equation—women and racially underrepresented people who together compose well over half of the U.S. population.

This author's literature review failed to reveal research linking economic elements to actual graduation rates in engineering. Much of the research evaluates retention in the first year since attrition is so high at that time (Kezar, 2000; Lang, 2001; Maton, Hrabowski, & Schmitt, 2000; Morrison & Williams, 1993; Schrader & Brown, 2008; Tinto & Love, 1995). The variables under study typically include the students' inherent traits (perseverance, attitudes towards the field) and the elements in the university environment that affect retention. Two studies were found that have shown the number of students who remain in the engineering major to graduation and the traits of actual graduates prior to their arrival in college. The following studies associate college graduation with parenting and with high school math preparation. Grief, Hrabowski and Maton (2000) identified traits of African American mothers of sons enrolled in or graduated from the Meyerhoff Program at University of Maryland, Baltimore County. The Meyerhoff Program is a multicultural retention program designed for students who enter college majoring in technical fields with a High School GPA over 3.5. Students receive financial scholarships, are housed together, assigned a mentor and are exposed to programming that deals with math and science topics and the African American experience. This program has a 90 percent college graduation rate.

In this study, 38 of 50 mothers agreed to be interviewed. The interviews included open ended questions focusing on the mother's family background and messages she received about education and gender roles. All mothers lived with their sons when they were home from college, 60 percent were married. Their average age was 47. Two thirds of the group completed college, half of those completed some graduate education. All were involved in their son's precollege education monitoring homework and attending parent conferences. This group was better educated and more likely to be living with a husband than was typical African American women of their age in the U.S. according to data from the U.S. Census Bureau at that time. Findings showed several themes that emerged. The mother's family was typically a hierarchical structure where hard work and discipline were emphasized. Education was expected and valued, while gender roles were evenly split between those families where various responsibilities were shared or gender-defined. Religious practices, such as going to church, was another common factor. Although the study suggests that traits of the parents could be associated with the likelihood of graduation, parenting traits are not tangibles items that can be easily changed or controlled.

On a more tangible level, Russell and Atwater (2005) interviewed 11 African American undergraduate seniors majoring in Biology seeking to find those elements most affecting persistence through graduation. Although these students were not majoring in specifically in engineering, Biology is a technical field with similar entry-level academic requirements. One of the most critical factors identified by students was high school participation in college preparatory math and science courses. Additional factors included family support, teacher encouragement, intrinsic motivation and perseverance.

Were more known about the factors leading to graduation (rather than single year retention), definitive tangible solutions could be applied to resolve the problem. It also

may be argued that an increase in the number of engineers would result from increasing family income by increasing the number of jobs in high-poverty/low-income areas, thereby increasing the tax base and enabling local schools to gain the resources needed to provide a better education. The number of math and science teachers could be deliberately increased as was suggested by President George Bush during the 2006 State of the Union Address (Bush, 2006). Schools could increase the level of math offered to all students, especially those most likely to be shut out of the technical fields.
Examples of successful high school engineering preparatory programs include Project Lead The Way (PLTW) (Cech, 2007). The goal of this program is to increase the number of Americans in engineering through high school preparation. The program includes a four year sequence of math and science courses and engineering projects. Teachers take two weeks of training to teach the PLTW curriculum. In 2007, the program enrolled 175,000 students at 2200 schools in 49 states.

A program assessment of PLTW was completed by the evaluation firm, TrueOutcomes, Inc. (2006). Data taken in an online format included 20 states, 75 schools, 3700 students, 900 seniors and 1600 reported grades. The assessment of 2005-06 showed that the racial and ethnic populations of the schools proportionately reflected the populations of the participating states in which schools were located. However, the racial and ethnic populations of the *PLTW courses* was proportionate to the school, with exception of African Americans which were underrepresented in the schools with large African American populations. Nationally, 70% of PLTW participants are White students, 4% Asian, 8% African American, 10% Hispanic, 1% Native, and 7% other or not reported. For racially underrepresented students, these percentages exceed the proportion of students enrolled nationally in college engineering programs which stand at about 5% for African Americans, 6% for Hispanic students and less than 1% for Native Students. Of the 900 seniors assessed, over 80% planned to attend college, compared to 63% nationally, and about 60% indicated an intention to study Science, engineering or a technical topic compared to the national average of 25%. For PLTW alumni, 45 college transcripts were analyzed showing that the average grades in Calculus, chemistry and physics are B's or better. The average College GPA is above 3.0. Project Lead The Way was recommended as a national model for the expansion of engineering education by the National Academy of the Sciences (2005). Project Lead the Way is not without cost. A typical school program can cost up to $95,000, while teacher training can exceed $2000 per teacher.

In 2001, the state of Massachusetts implemented an engineering K-12 curriculum for its public schools, not only increasing the math requirements, but exposing students to creative engineering concepts in stages designed for kindergarten and each of the twelve grades. The Massachusetts Science and Technology/Engineering Curriculum Framework (Massachusetts Department of Education, 2006) identifies ten Guiding Principles to assist educators in establishing effective engineering curriculums for the Massachusetts school system. These principles suggest that effective science and technology/engineering programs should do the following:

- Enroll all students
- Build student's understanding of fundamental technological concepts
- Be integrally related to Mathematics
- Address students prior knowledge

- Include experimentation and problem solving
- Build on literacy skills
- Convey high expectations
- Include assessment

Guiding Principle XI states, "An effective program in science and technology/engineering gives students opportunities to collaborate in scientific and technological endeavors and communicate their ideas" (Massachusetts Department of Education, 2006. p. 17). This would include advanced academic study and career opportunities in engineering and similar fields. Outcomes regarding the career choices of Massachusetts high school seniors that have completed the entire 12 year program will not be available until the year 2013 or later. It is expected that a higher number of students are more likely to self select into technical careers (Fewster, 2001). The long term projects undertaken by the Massachusetts Department of Education and Project Lead The Way are examples that support the suggestion that lower math SAT scores are not necessarily a sign of inaptitude, but may reflect a lack of funded preparation that can be remedied.

Although college retention programming was not one of the tangible economic factors in this study, it is important to mention because it has proven to be critical to the graduation of underrepresented engineers over the past 30 years (Grandy, 1995; Guthrie, 1992; Kezar, 2000; Landis, 1985; Roach, 2006; Tinto, 1975, 1987). Grandy (1995) pointed out that even underrepresented students who do well in high school math courses may not continue in their chosen engineering majors if retention support systems are not in place at the colleges they attend. These support systems should include environments that provide community, encouragement to continue the development of advanced math skills, and mentoring and interaction with other technical students. Math-intensive summer bridge programs are successful because they compensate for math inadequacies at the high school level, while at the same time providing community through a cohort that will engage in the engineering learning experience together. This was demonstrated by Guthrie (1992), who placed students scoring lower on standardized math tests in a math-intensive summer bridge program. It was found that these students had a higher probability of passing college math courses and completing bachelor degrees. Yet, while summer bridge programs have demonstrated success in increasing the graduation rate for underrepresented engineers, they are expensive to operate (costs typically include renewable scholarships, additional technical instruction, housing, summer credits, hands on technical exposure) and thus economics comes into play once more (Maton, Hrabowski, & Schmitt, 2000). Were funding conditions deliberately changed, the yield could be more domestic engineers in the future.

Research Questions

Research questions addressing the academic and economic factors related to the graduation of racially underrepresented engineers were as follows:

1 Is there a significant difference between the high school math and academic preparation (high school GPA, SAT score and FTCAP score) of those students who start in engineering and graduate in engineering, and those who start in engineering and do not graduate at all? What is the correlation between math preparation and the likelihood of graduation in engineering?

2 Is there a significant difference in the high school math and academic preparation (high school GPA, SAT score and FTCAP score) of those students who start in engineering and graduate in engineering, and those who start in engineering and graduate with other degrees? What is the correlation between math and academic preparation and the likelihood of graduation in other majors?

3 For students who begin in engineering, what is the correlation between the high school community economic index (CEI) and the following math and academic indicators: SAT score, FTCAP math score, high school GPA?

4 For students who begin in engineering, what is the correlation between the high school CEI level and the likelihood of the following graduation outcomes: graduation in engineering, graduation regardless of major, non-graduation?

Because math success is critical in the engineering major, it was expected that the math preparation (SAT, FTCAP) of graduating engineers would be higher than that of those who graduate in non-technical fields as well as those who do not graduate (Fleming, 2000; Gilmer, 2007; Guthrie, 1992; Russell & Atwater, 2005). Several studies positively correlate engineering academic success with precollege math preparation whether through high school or summer bridge programs preceding the first semester in a university technical program. It was expected that high school GPA would prove to be similar for graduates and non-graduates since all are generally accepted into engineering with GPA as a heavily weighted factor. Findings for research question 3 were expected to show that math preparation is negatively correlated with community economic index (poverty level). This could indicate a lower availability of local funding resources for the high school. Overall, the family incomes of the high school community, SAT scores, and high school math levels of engineering college graduates were expected to be higher than those of non-graduating students. For research question 4, a negative correlation was expected between the community economic index in the high school community and the graduation rates of engineers and non-engineers alike. A positive correlation was expected between the high school community economic index and non-graduation of those beginning in engineering.

Definitions

The term *underrepresented* refers to U.S. Citizens and permanent residents of African American, Native and Hispanic descent. In 2007, African Americans composed 11.0% of the total workforce while Hispanics composed 14.0%. For engineering occupations, however, African Americans and Hispanics composed 5.3% and 6.4% respectively (Bureau of Labor Statistics, 2007). These groups are not evenly represented in all areas of the workforce and are underrepresented in the engineering profession.

For the purposes of this dissertation, the term *graduation outcomes* refers to any of the following three outcomes for entering engineering students five years later: engineering graduates, other (non-engineering) graduates, non-graduates. The term *engineering graduates* or *graduate engineers* refers to those who begin in the Penn State College of Engineering as first-year students and graduate within five years from the College of Engineering with bachelor degrees. It does not include students who have transferred into engineering after the first year from another university or another major. The term *non-graduates* refers only to students who began in engineering but ultimately did not graduate from Penn State University. The term *other graduates* refers to those students who started out in engineering but graduated in other majors.

In the field of workplace learning and performance (WLP), the term *intervention* is defined as “a corrective action” designed to improve the performance of employees. In this dissertation, students are treated as new employees, and interventions are assumed to be *proactive interventions* that, by definition, are “intended to avert or avoid future problems” as well as focus on “seizing new opportunities for performance improvement” (Rothwell & Sredl, 2000, p.7-8). Problems could include employment access or promotion as well as employment performance. Here the term intervention is used to refer to remedies designed to halt attrition and retain those starting the degree in the first year. The most common interventions designed to retain students entering engineering are Multicultural Engineering Program (MEP) services and summer bridge programs.

A *Multicultural Engineering Program* (*MEP)* is a group of services offered in a university setting for the purpose of recruiting underrepresented students to engineering, reducing the dropout rate and increasing graduation rate (Landis, 1985; Roach, 2006). A *summer bridge* is a four- to six-week math-intensive residential program attended by incoming engineering college students during the summer following high school graduation (and preceding fall admission). Summer bridges are typically offered through the MEP. Students review calculus and other entry-level technical courses. A pseudo-college environment is created. Student form a learning community with others of their cohort and adapt to studying technical courses together and assisting each other. Studies show that these programs are among the most effective retention tools for underrepresented students entering engineering and lead to higher grades and graduation rates than those for non-participants (Kezar, 2000; Maton, Hrabowski, & Schmitt, 2000; Taylor & Miller, 2002; Tinto, 1997).

A*nticipatory socialization* is defined as the process of gaining knowledge about work that begins in early childhood and continues until entering the workplace full time (Jablin, 2000; Levine, 2006). It includes a wide range of influences that inform one's career path. This range includes role modeling observed during childhood, to information passed on from others regarding certain occupations, to internships taken in college.

The *community economic index (CEI)* is determined by the percentage of students in the public high school receiving free lunch. Although this number does not directly show high school funding level or family income, it does show the economic income level of families in the community (with high school-aged children), and has implications for the available tax base funding at that school. This economic indicator was also used in assessments of Project Lead The Way (described earlier) to determine the effectiveness of the math program on low-income populations (Cech, 2007). Initially, school funding levels were identified, but it was difficult to tell what funding amount was sufficient to provide adequate resources for schools in various states and under various economic conditions. The school lunch indicator is available for every individual public school and is a uniform indicator of the economic conditions of those attending and the surrounding community.

Penn State Data Warehouse is a database containing variables for all students and alumni, including: major, date of admission, high school attended, high school and college GPA, SAT scores, change of major, withdrawal date, graduation date and much more information. (See Appendix A for a sample of data available.)

Limitations

Information about the sample was taken from the official long-term student records of The Pennsylvania State University stored in the Penn State database, Data Warehouse, and the data files of the National Center for Education Statistics (NCES), provided through the U.S. Department of Education, Institute of Educational Services. Data Warehouse is a collection of Penn State student data that provides information on students from admissions through graduation within a given major. The limitation of using the Data Warehouse information is that it does not readily identify students who transfer from other majors into engineering and begin after the first year. Through the NCES system, the sample only includes students who attended public schools in which the percentage of students receiving free or reduced lunch may be identified for each high school. This eliminates those who attended private high schools where no community income information was available.

Study findings are applicable to a population of underrepresented students attending the top 25 engineering colleges in the U.S., all of which are majority universities with well-funded research programs. Findings may not be applicable to students attending the Historically Black Colleges and Universities (HBCUs), Hispanic Serving Institutions (HSIs) or Tribal Colleges, which are equipped to address issues of racial isolation and assist specific groups of students from economically under-resourced backgrounds.

This dissertation did not consider extenuating individual circumstances or any other factors that would assist retention efforts, such as participation in summer programs, input from mentors or family support. This is important to recognize because graduation or non-graduation cannot be entirely attributed to economic factors. The study also was confined to engineering graduates. Many non-technical majors who leave engineering arrive in another field because of a personal preference, not because of lack of success, aptitude, funding or preparation in engineering. Similarly, this dissertation did not identify those who left college due to inadequate long-term funding for college (financial aid or scholarships), a related economic problem that reveals itself after college entry rather than before.

Although this dissertation identified the significance of formal retention programming, it failed to identify all of the informal events that are instrumental in producing many underrepresented graduates nationally, including those studied here. This dissertation considered but a few of the economic-related factors and not the entire experience of the student.

This dissertation contrasted events at two given points on the academic timeline: high school graduation and the point at which the student exited college (with or without a degree) up to five years later. There are other factors in between these two points that would increase the likelihood of graduation or drop-out that are not accounted for here (such as student organization participation or personal tragedy).

Finally, it cannot be said that students who exit Penn State do not become engineers. In fact, the same negative financial circumstances contributing to the "non-graduate" label in this dissertation could have also prompted the exiting student to transfer to a less expensive university, resulting in graduation with an engineering degree nonetheless.

Assumptions

It was assumed that the population served is racially underrepresented, mathematically talented but more likely to be economically disadvantaged, often attending underrepresented high schools. Communities are often under-resourced and students who otherwise could be engineers are not always encouraged to pursue this path for a variety of reasons. It was assumed that economics intertwines with many of these reasons, and that some groups are systematically shut out of the engineering occupation early on due to the economic conditions of their parents and community, which affect educational achievement (Ku & Plotnick, 2003; Winglinsky, 1998; Zhan & Sherraden, 2002).

Theoretical Framework

The theoretical framework for this dissertation was based on Tinto's extensive research which set out to define those elements that affect learning and persistence behaviors of college students (Tinto, 1975, 1982, 1987, 1988). Tinto's earlier work focused strongly on the first college year in which higher attrition is most likely to occur. The elements most examined include those that are composed of human interaction and relationship-building such as tutoring, faculty interaction, cohort formation, and students' beliefs about their own likelihood of success (Tinto, 1999; Tinto & Love, 1995). Whereas Tinto collected qualitative and quantitative data to define relationships through surveys, typically over a one-year time period, this author collected quantitative data through secondary sources on engineers who had graduated over a five-year period, comparing their admissions records to those of their peers who graduated with other degrees or did not graduate at all. In 2008, Engstrom and Tinto completed a four-year study which showed that the enhancement of those elements affecting retention is effective throughout the academic tenure of the student, increasing the likelihood of graduation by low-income students and those who do not appear to be academically prepared upon college entry. The subjects of Tinto's studies are not major- or race-specific. Therefore, those details that may differ based on major (academic departmental culture) or race are not clearly identified in Tinto's work.

This dissertation continued Tinto's search for variables affecting student retention and graduation with the following modifications:

1) The variables affecting retention were those dictated by economics prior to college entry rather than after.
2) The time-line examined was longer, spanning from the final year of high school through college graduation or exit.
3) The audience was narrowed to racially underrepresented students studying engineering.

The goal of this dissertation was to correlate pre-college variables with actual graduation in engineering. This is supported by Tinto's more recent findings regarding the importance of promoting the success of low-income students and the equal importance of understanding the experiences of students from different backgrounds (Engstrom & Tinto, 2008; Tinto, 2007).

This dissertation used Tinto's framework to evaluate the correlation between those pre-college economic and academic factors that are related to the graduation outcomes of underrepresented college graduates in engineering five to six years later. Additional information regarding Tinto's work is covered in the literature review in Chapter 2.

Chapter 2

REVIEW OF RELATED LITERATURE

Introduction

Research has shown that the educational success of those underrepresented students who choose engineering is directly correlated with early socialization, economic resources available to fund required academic preparation prior to college entry, and retention efforts needed to ensure college graduation. Therefore, this chapter contains a review of research on the following related topics:

- Career Choices and Development
- College Retention Programming
- Racial Bias in Employment Practices and Perceptions
- Economic Factors Related to Education Access

Each of these factors is important in determining the likelihood of a student choosing to pursue engineering as a profession. These factors are also interrelated. For underrepresented students, career choices are identified early in childhood and subject to surrounding perceptions of family, employers and educators, many of which are tied to racial and economic politics in the U.S. The college retention programs are designed to rectify problems once students enter the university as engineering majors. Tinto completed extensive research on the topic of college retention and those factors affecting retention after students enter college (Tinto, 1975, 1982, 1987, 1999). Tinto's research methods and philosophy also included those retention factors that are in place before students enter college. Of these closely related subjects, the fourth element—economic factors affecting educational access to the field of engineering—was the focus of this study. Those economic related factors affecting access to the college major include: family income, high school funding, high school math level, high school GPA, and SAT scores. If students are unable to access the field, engineering will continue to lag in its efforts to increase its numbers. Each of these four areas is discussed in the following sections.

Career Choices and Development

Career choices are made through *anticipatory socialization.* This term is defined as “the process of gaining knowledge about work that begins in early childhood and continues until entering the workplace full time”(Levine, 2006, p.647). Jablin (2000) suggests that early vocational perceptions can come from several sources in this process including: family, educational institution, part time employment, peers, friends and media. Career development choices are also made based on economic resources and early socialization (Gray & Herr, 1998). Those considering a technical career should keep several factors in mind, such as early role modeling, exposure to the field, good math preparation and educational systems. *Workplace learning and performance* (WLP) is defined by Rothwell and Sredl (2000, p. 2) as “the integrated use of learning and other interventions for the purpose of improving individual and organizational performance. It uses a systematic process of analyzing performance and responding to individual, group and organizational needs. WLP creates positive progressive change within organizations by balancing human, ethical, technological and operational considerations.” In the case of incoming underrepresented engineers, the actual *performance* involves completing entry-level academic training and actually entering the field of engineering. This performance is directly associated with the ability to balance the future employee's ethnic culture while developing a comprehensive understanding of the expectations of the European business culture being entered. At the same time, these incoming employees are aware that they are not always perceived as being equal to their counterparts of European descent entering the field of engineering (Waldinger & Lichter, 2003). Professional development includes lessons to be learned and performed that exceed the traditional academic coursework provided to most students in a university setting, but go further to include negotiating that work in a context and culture not previously experienced by them. For underrepresented engineers, this is additional information that is provided by the college retention programs.

Among successful professional African American engineers, when asked, few can give definitive advice about how to increase their numbers. Most refer back to early socialization methods and barriers that would allow or prevent new engineers from entering the field (Miloy, 2002; Phillips, 2002; Sabathia, 2005). All encourage the raising of public awareness in African American communities regarding technology usage and careers. In 1999, the first Black Family Technology Awareness Week was launched ("Technology awareness aims to help transform lives of blacks", 2005). The intention was to begin turning the tide towards technology careers for the next generation.

College Retention Programming

The retention of college students has been researched broadly, revealing a wide range of well-established factors that contribute to graduation. Those factors that apply to the broader population must sometimes be modified for specific samples—in this case, underrepresented engineering students at predominantly White institutions. Here, the conventional recommended social support structure must also include math-intensive programming early on to be effective.

Tinto (1975, 1982, 1987, 1988, 1995) has long theorized that several factors may be put into place to affect college retention (or persistence) of a wide range of students in the first year of university study. Academic and student support services need to be front-loaded because research demonstrates a high attrition rate during the first year of college. In order for students to be retained, they need to develop their skill competencies and confidence in their ability to perform well academically. This can be done by: a) increasing the number of minority faculty members; b) establishing mentoring programs; c) assigning academic advisers and support services counselors; d) arranging for consistent financial aid presentations; e) gaining access to tutorial services focusing on mathematics and the sciences; f) implementing first-year seminars for incoming first-year students and transfer students; g) instituting communities of learning such as special housing options; h) arranging for book and tuition scholarship programs; i) clustering core engineering courses taught by selected faculty members; j) working in conjunction with internship or cooperative education programs; and k) establishing pre-college programs and college-summer-bridge programs.

Much of Tinto's focus was on the on the creation of "learning communities." The principle of the learning community is based on the idea that students and professors who share two or more classes together will assist each other in building positive social relationships and achieving academic success. The goal is achieved through altering the traditional classroom experience to deliberately include collaborative learning strategies. Courses are linked to each other through subject matter, continuing faculty, or continuing attendees so that students experience learning as a shared experience. Examples of this are particularly clear in Tinto's 1997 study which identified social and academic activities that influence persistence in the Coordinated Studies Programs (CSP) at Seattle Community College. CSP was designed such that students enrolled in several courses together with a unifying theme rather than stand alone courses. All faculty was present in all courses. Students met for a total of 11-15 hours weekly. This created an environment of interdependent learning that required active involvement with peers.

Samples included 121 CSP first year students from four liberal arts courses, and 166 first year students enrolled in similar non-CSP courses. Questionnaires were given at the beginning and end of the fall quarter. Findings revealed that students were significantly more involved in the following activities: courses, library, interaction with faculty, interaction with other students, writing, clubs and the arts. The most significant (p=.05) of these being involvement with other students and courses. In addition, CSP students had significantly more positive views of college, other students, faculty, administrators, the campus climate and themselves. Retention was measured through re-enrollment rates. Re-enrollment for CSP students was higher at 83.8% for Spring and 66.7% for the following Fall. For comparison students, the re-enrollment rate was at 80% for Spring and 52% for the following Fall. Five factors of 24 measured proved to be predictors of persistence. They were (in ranking order starting with the element of highest significance): CSP participation, college GPA, hours of study per week, participation in student activities, perception of other students.

In a similar earlier study at Laguardia Community College (LCC), Tinto and Love (1995) compared three learning communities to traditional students at LCC taking similar courses. The three learning communities focused on students in liberal arts (n=49), business careers (n=52), developmental courses (n=25). They were compared to other students who were not participating in a learning community (n=211). Findings in this study showed that those in learning communities had a slightly higher persistence rate one year later (77.7% versus 75.9%) and higher college GPAs than traditional students, even if high school grades were lower. Of significance were the responses to questions regarding the students' intentions to continue from the two-year institution to a four-year institution. The learning community participants were more likely to express an intention to continue (88.5 %) than traditional students (77.9%) at a level where p=.05.

In more recent research, Tinto (2007) added precollege academic preparation and financial assistance to the list of elements that contribute to the persistence rate of students in the first year. Tinto (2007) made it clear that although learning communities are effective across broad populations, more study needs to be done with specialized populations, especially low-income populations.

Engstrom and Tinto (2008) went on to apply the learning community philosophy to an academically underprepared, low income student population using the following methodology. Students sampled were enrolled in 13 two-year and six four-year colleges in 11 states. All institutions were identified as having effective developmental learning community programs. At all 19 institutions, a comparison group of students were also selected taking similar courses outside the learning communities. The final sample (N=5729) included 2617 students from the learning communities and 3114 students in comparison class rooms. Students were surveyed to identify levels of academic engagement, perceptions and academic plans. Student performance was tracked over three years and persistence (re-enrollment) was tracked over two years. Findings showed that low-income learning community students were more academically and socially engaged and more apt to persist to the following academic year. The positive difference in persistence ranged from 5% to 15% across all institutions. Students listed those elements they believed accounted for these results. Contributing factors included:

- Having a safe place to learn
- Having a supportive place to learn
- Having a sense of belonging in college
- Being enabled to learn more.

Tinto identified institutional commitment and support services as contributing factors to increased student retention. In a forty-year overview of the topic of student retention, Tinto (2007) noted that:

> When the issue of student retention first appeared on the higher educational radar screen, now some 40 years ago, student attrition was typically viewed through the lens of psychology. Student retention or the lack thereof was seen as the reflection of individual attributes, skills, and motivation. Students who did not stay were thought to be less able, less motivated and less willing to defer the benefits that college graduation was believed to bestow. Students failed, not institutions. This is now what we refer to as blaming the victim (Tinto, 2007, p.2).

Tinto goes on to say that in four decades, we have learned that one of the primary keys to student success is long term institutional investment in good student retention programming and faculty-student interaction.

For underrepresented engineering students, one of the primary support services is the Multicultural Engineering Program (MEP) through which learning communities are created. As mentioned in chapter 1, the MEP is a group of services offered in a university setting for the purpose of recruiting underrepresented students to engineering, reducing the dropout rate and increasing the graduation rate. MEP directors may be viewed as *intervention designers* as well as *intervention implementors* according to the definitions provided by Rothwell and Sredl (2000, p. 113), in that they "create learning and other interventions that help to address specific root causes of human performance gaps," and they "ensure the appropriate and effective implementation of desired interventions." Interventions provided by MEP directors could be categorized as employee *orientation training*, giving these potential workers rudimentary information about typical cultures and expectations in engineering organizations. It may seem very preliminary to be placed in this category; however, studies show that if this information is not provided early on, many of those in this group will not statistically ever enter or be accepted into the engineering field (Guthrie, 1992), even those students with high math abilities (Grandy, 1995).

Newcomer orientation is a term that is widely used, but not consistently defined (Wanous, 1992). The problem with definition of this term is in determining when the orientation phase begins and ends, and when the next stage of long-term socialization begins. It can last from a day to a week. Orientation is needed to off set high stress levels associated with changing occupations, or entering a new occupation. Wanous (1992) contends that newcomers experience the highest levels of stress immediately after entry more than any other time in the organizational socialization process. For this reason, many organizations commonly carry out some variation of orientation programming. Wanous provides several tips for designing Realistic Orientation Programs for Employee Stress (ROPES). These include:

- Include realistic information
- Provide general support and reassurance
- Use models to show coping skills and discuss actions
- Teach self control of thoughts and feelings
- Specific stressors should be targeted to specific newcomers (Wanous, 1992, p.152).

Students indicate their intention to enter an occupation by enrolling in college and declaring a major, such as engineering. Several of the ROPES techniques are incorporated to create effective multicultural engineering retention programs discussed further in this chapter.

Anticipatory socialization of entering underrepresented young adults is the key to this process. In this research, the most studied method of successful anticipatory socialization affecting retention was the college summer bridge programs designed for entering engineering students. Though there are many variations, a typical summer bridge program accommodates a limited number of students (15–35) and is offered in the summer prior to the fall of the students' first semester. These students review calculus, chemistry or physics, and English to ensure success in first-year courses they will take in the fall. Students may also receive professional development training with some form of ongoing mentoring. According to Wheatland (2000), summer bridge programs before the first semester of college were not significantly effective in the retention of most underrepresented students. Engineering students were the exception in that study.

Following are research findings regarding the elements to be emphasized in a successful program as well as the challenges observed in bridge programs. Retention rates of African American, Hispanic and Native American students in engineering are nationally problematic. This is true at Historically Black Colleges and Universities as well as at majority universities. African Americans are only half as likely to graduate as their White counterparts (Georges, 1999).

Those factors which render a program effective are viewed in multiple ways. According to Kezar (2000), the most successful summer bridge programs address self-confidence, college expectations, the connection of college and community, validation within the college, and family understanding of the process. Taylor's (2002) study of the persistence of African Americans on predominantly White campuses suggested that persistence is associated with four specific factors: leadership opportunities, social integration, worth and competence, and ethnic peer attachment. All of these elements should be emphasized strongly within the program and its design. The earlier and longer the orientation program, the more effective it is (Kleupfel, 1994). Orientation should enforce high expectations of the college experience with follow-up after the program. Even armed with this information, MEP staff still find it more difficult than anticipated to convince students to take advantage of the summer bridge opportunity (Freeman & Persaud, 2005). This response also was observed in Robert's (1994) examination of summer bridge programs, where he noted the difficulty experienced by students in overcoming resistance to seeking help or not recognizing that help is needed. Special effort must be made to address stigma associated with being in remedial programming. Robert suggested that this stigma and resistance can be countered by building a peer community and by small group collaboration.

York and Tross (1994) suggested that retention effectiveness could be more accurately measured if it also included a comparison of first-quarter grades with those of non-participants, and if students were tracked to see if survey information is predictive of retention. Persaud and Freeman did this with the PreFirst Year in Engineering and Science (PreF) Program at The Pennsylvania State University. Fifteen years of data showed that students completing the PreF Program had a mean retention rate that exceeded that for majority males (Persaud & Freeman, 2005).

Racial Bias in Employment Practices and Perceptions

National racial perceptions of racially underrepresented Americans in the U.S. have historically been negative (Florida, 2002; Waldinger & Lichter, 2003; Wilson, 1997). It is not surprising that this attitude is reflected in the area of domestic employment preferences. In Florida's (2002) book, The Rise of the Creative Class, it was concluded that the most probable geographic locations for technological centers are those proximate to creative people and creative centers. The "creative class" gravitates towards locations filled with diversity, defined as inclusion of people from all backgrounds and cultures (international, transgender, men and women, economic classes, etc.). At first, it would seem that African American people would be more accepted by this new creative class as it rises to power. But examination of 260 pages of data, including the Gay Index and the Bohemian Index, among others, revealed a small paragraph that clearly shows that “diversity” in this study does not include African American and non-White populations.

> …there is a gaping hole in this picture. The diversity picture does not include African-Americans and other nonwhites. As noted earlier, my statistical research identifies a troubling negative statistical correlation between concentrations of High-tech firms and the percentage of the non-white population…It appears that the Creative Economy does little to ameliorate the traditional divide between white and non white segments of the population. It may even make it worse (Florida, 2002, p. 262).

While Florida suggested that the next group in power would be the educated, technology-oriented “creative class”, there seems little probability that this group, so attracted to diversity, would do much to improve the technological employment outlook of African Americans and other non-Whites.

Waldinger’s (2003) study of the hiring practices of employers favoring undocumented workers went further to reveal that employers also preferred undocumented workers to African American workers because of racial preferences and preferences for subservience towards employers. Many employers felt that African Americans were not subservient enough and wanted to be treated fairly rather than demeaned, whereas undocumented workers were very subservient and typically asked for little. Waldinger went on to describe a “hiring queue” such that those seeking employment are categorized in an order based on stereotypes that define a particular occupation. (For example, women would be at the front of the “hiring queue” for nursing jobs.) This raises the question: Who is most likely to be viewed as an engineer? In the U.S., African, Hispanic and Native Americans do not typically come to mind in discussions of technical positions (Wilson, 1997).

Wilson’s (1997) research suggested that African Americans, among others, face the most negative employer perceptions regarding qualifications and work ethic. This proved especially true for inner-city workers, such that very young Black males were most likely to be initially perceived as uneducated and unstable. When all of these findings are applied to underrepresented people (primarily males) attempting the engineering field, an existing racial bias emerges that needs to be addressed before the figures can be dramatically changed.

Economic Factors Related to Education Access

Attainment of the bachelor of science degree in engineering is critical to entering the field. Admission to a college of engineering is strongly based upon the development of the student’s math skills. Whether a student receives training in math is largely tied to several interconnected variables, many of which are economically linked. Four of the factors important to this dissertation were family income, funding available to the high school, math level offered by high school attended, and high school GPA and SAT scores prior to college entry. Each of these factors is discussed further below.

Family Income

Family income dictates and implies several things. It can determine the extent of a student's level of exposure to educational resources, from tutoring to special workshops and media. It determines whether students have access to computer and other electronic resources. In a broader sense, income dictates where families live and the local tax base that funds public schools. Schools located in communities that include wealthier tax payers have a wide range of educational resources, such as qualified teachers, current textbooks and laboratories, and a wide range of subjects available for study (Yeung, 2008). Schools that receive less tax support from poorer residents will often be under-resourced. As budgets are cut, math and science are often the first to be diluted or eliminated, preventing those students from entering fields that require strong math and science skills such as engineering. Because African American and Latino populations are among the poorest in the nation, these students are more likely to be automatically eliminated from competing early on, simply because of their family income (The Education Trust, 2003).

According to a longitudinal study of 8th-grade students from 1988–2000, over half of Latino and African American students come from families with incomes less than $25,000 per year, while only 7% exceeded $75,000 per year. In addition, 58% of Latinos and 63% of African Americans were not qualified or prepared for college after high school (Swail, Cabrera, & Lee, 2004).

There were several studies of families receiving welfare and the educational attainment of the children in those families. Ku and Plotnick (2003) studied family income data over a 15-year time period. It was determined that greater exposure to welfare is significantly associated with children's poorer educational attainment. This was particularly true in adolescence. On the other hand, research gathered from data covering a shorter time period suggested that the increase in parent-child interaction time created by the receipt of welfare income positively affects children's educational attainment (Wilson, Ellwood, & Brooks-Gunn, 1995). Conclusions differ, but another possible factor affecting educational attainment could well be access to educational resources through either the parent or other resources requiring monetary investment. When children are young, the parent is able to provide age-appropriate information to assist the child's educational success. By adolescence, many parents have fewer educational skills to assist the student, especially if the student takes courses that exceed the parent's knowledge. The parent would then depend on the school system to fill in the gaps; however, those receiving welfare are, by definition, poor. Consequently, recipients of welfare are more likely to attend under-resourced public schools due to a lower tax base of support.

Zhan and Sherraden (2002) examined the effects of mothers' assets (home ownership and savings) on their expectations and their children's educational achievement. They found that single mothers' assets had significant positive effects on their expectations and their children's educational achievement in female-headed households. Interestingly, savings had an effect on children's probability of high school graduation and home ownership had a positive significant effect on academic performance. Again, the more money available to a family, the more they have to invest in education.

Family income continues to determine the success of the student even in college for those who do enter engineering, such that financial aid becomes crucial. Many students participate in a range of retention programs to ensure their success in engineering. Yet, at the end of the program, even a well-run program, financial aid is still a critical factor in the retention of underrepresented students (Georges, 1999; Lang, 2001).

Tinto (2007) points out that it is common to associate the issues related to poverty with those related to race, but these two items are not the same, and should be reviewed separately to accurately differentiate the effects of income from the effects of race, as well as the effects of the combination. Racially underrepresented students in four-year institutions are more likely to be middle class because of the higher cost of attendance versus those in two-year institutions. Low income students are more likely to be less academically prepared when starting college than their more affluent counterparts, regardless of race. Because they begin with fewer academic resources, they are less likely to continue to graduation (Tinto, 2008).

High School Funding Level

There is a significant difference in the achievement gap between poor and non-poor students in the U.S. public school system. This is a direct reflection of the correlation between school funding levels and local tax bases. As a consequence, low-income students tend to attend poorly resourced schools (The Education Trust, 2003; Wenglinsky, 1998).

The variability in funding levels for public schools is problematic in the United States. Often if funding is cut, math and science courses are among the first to be reduced. The Campaign for Fiscal Equity, Inc. (2003) filed a lawsuit against New York State on behalf of New York City students in the late 1990s. They charged that the state unconstitutionally underfunded city schools. This charge was supported by the Court of Appeals, which held that the city must ensure that every school in the state had sufficient resources to provide students with a "sound basic education." However, in 2002, an Appellate Court held that the state constitution only guarantees that schools provide the opportunity to learn at an 8^{th}- or 9th-grade level, and that current funding was adequate. This was overturned and the case was sent back to trial court, but it is clear that a "sound basic education" is not defined equally by all. Access to adequate math levels would require a state to commit to funding math-appropriate resources through grade twelve.

Students most likely to attend an underfunded school in the U.S. are African American, Native and Latino. Underfunded schools are less likely to have highly qualified teachers. About 25% of high school courses in the U.S. are taught by teachers lacking either a major or a minor in secondary education. Secondary classrooms in high-minority, high-poverty schools are nearly 80% more likely to be taught by under-qualified teachers. As a result, students who have two ineffective teachers in a row rarely recover, while those who have several effective teachers will excel regardless of family backgrounds. Nationally, in 2000, school districts with the highest child poverty rates received $966.40 fewer state dollars per child to spend, and districts with the highest minority enrollments received $902.23 fewer state dollars compared to those with the lowest minority enrollments. This is a total of $22,555 less per poor minority classroom of 25, than is spent on their wealthier, majority counterparts. The result is reflected in students' achievement levels in math and other subjects (The Education Trust, 2003).

Math Level

The college engineering curricula for entering students typically begin with math at the calculus level and calculus-based physics. Mathematical preparation of incoming students is critical for success. Underrepresented students are less likely to receive course work in high school that academically prepares them for college than their White or Asian counterparts. This lack of preparation is especially pronounced in math and science (Thomas, 2000). While 63% of those students taking advanced placement calculus courses are White, only 5% are African American and 7% Latino (The Education Trust, 2003). About 1 in 5 Latino or African American students are likely to take trigonometry, pre-calculus or calculus compared to 1 in 3 White students (Swail, Cabrera, & Lee, 2004). All of this would suggest that a high school or summer bridge program that enhances or reviews math and science concepts will better prepare students entering those majors. This is supported by the research, which shows that summer bridge programs that are most successful in engineering typically include intensive math review (Allen, 2001; Maton, Hrabowski, & Schmitt, 2000).

GPA and SAT Scores

High school GPA is still the best predictor of student performance in college (Hu, 2002). This is especially true for African American and Hispanic students. When GPA reflects strong math skills but SAT scores do not, the GPA becomes a measure of persistence rather than of current knowledge with regard to a math subject. When using the SAT to measure college success, the whole score is more accurate than a separate score, and the verbal score is a more accurate measure than the math score—except for students majoring in math, science or engineering. In that case, the math SAT is a more accurate predictor of the students' success if no other intervention is employed.

Even when underrepresented students do have SAT scores favorable to engineering and science, other interventions are often necessary for them to choose engineering as a major and persist. Factors affecting these decisions include gender, socioeconomic status, role modeling, and support programming at the college of choice. These factors are interrelated (Grandy, 1995).

Project Preserve is a program designed to retain minority engineering students who failed in the freshman year at predominantly White large institutions (Fleming & Morning, 1998). These students were placed at three institutions noted for their support services for minorities. By the conclusion of the 5-year program, 64% of the would-be dropouts were still retained in engineering. This study also showed that the SAT scores, a standard predictor of GPA, was not as accurate in predicting minority students' success and suggest that college adjustment be taken into consideration. Results also seemed to indicate that race was a factor and that students required less adjustment if they were African American students attending an HBCU. In this case, the SAT score was more accurate. The mean total SAT score for subjects was 961 (with a range of 670–1350, based on a maximum of 1600 possible). Although Project Preserve was very successful, one can only wonder whether better high school math preparation (among other retention tools) would have meant one less college adjustment factor for most of these students.

The other point clearly made in this study is that racial issues do create a barrier to minorities' access to engineering at the college level, just as it does at the professional level.

Summary

Research shows that career choices are directly associated with a wide range of variables that are social, economic and academic in nature. Each of these is intertwined with the others, contributing to the overall shortfall in numbers of racially underrepresented engineering professionals. The reasons students choose not to continue in engineering at a higher rate than their majority counterparts involve broader social issues and with parental employment, educational resources, math preparation, national views of racism and hiring practices, and first-hand role modeling.

College graduation in a 4-year technological field is the gateway to employment in engineering. For underrepresented students, getting through this gateway has proven to be a problem, with consequences that are impeding the diversification of the engineering workforce and resulting in too few engineers in the U.S. Current methods are not enough to increase the numbers as quickly as the engineering industry would hope. This implies that a national focus on early socialization, domestic employment and educational improvements in science and math are critical if the face of engineering is to change.

Chapter 3

METHODOLOGY

The purpose of this dissertation was to examine the relationship of four independent variables that were in place after high school graduation for actual graduating African American and Hispanic students in engineering five years later. These factors included Scholastic Aptitude Test (SAT) math scores, calculus preparation level as identified through the Penn State First-Year Testing, Counseling and Advising Program (FTCAP) score, high school grade point average (GPA), and community economic index level of the public high school attended (CEI—which indicated the percentage of students qualifying for free or reduced cost lunch).

Research Questions

This dissertation involved four research questions:

1 Is there a significant difference between the high school math and academic preparation (high school GPA, SAT score and FTCAP score) of those students who start in engineering and graduate in engineering, and those who start in engineering and do not graduate at all? What is the correlation between math preparation and the likelihood of graduation in engineering?

2 Is there a significant difference in the high school math and academic preparation (high school GPA, SAT score and FTCAP score) of those students who start in engineering and graduate in engineering, and those who start in engineering and

graduate with other degrees? What is the correlation between math and academic preparation and the likelihood of graduation in other majors?

3 For students who begin in engineering, what is the correlation between the high school CEI and the following math and academic indicators: SAT score, FTCAP math score, high school GPA?

4 For students who begin in engineering, what is the correlation between the high school CEI (poverty level) and the likelihood of the following graduation outcomes: graduation in engineering, graduation regardless of major, non-graduation?

To answer these questions, a series of descriptive statistics, nominal regression analyses, multinomial logistic regression analyses were run on data indicating the correlations of each of the four variables (SAT, GPA, FTCAP and CEI) with each other and with graduation outcomes (defined as engineering graduates (EGRADS), other graduates (OGRADS) and non-graduates (NGRADS)). The goal was to determine how engineering graduation outcomes and math preparation are related, and how poverty (CEI) affects both of these factors. A flowchart showing the process of data collection is shown in Figure 3.1.

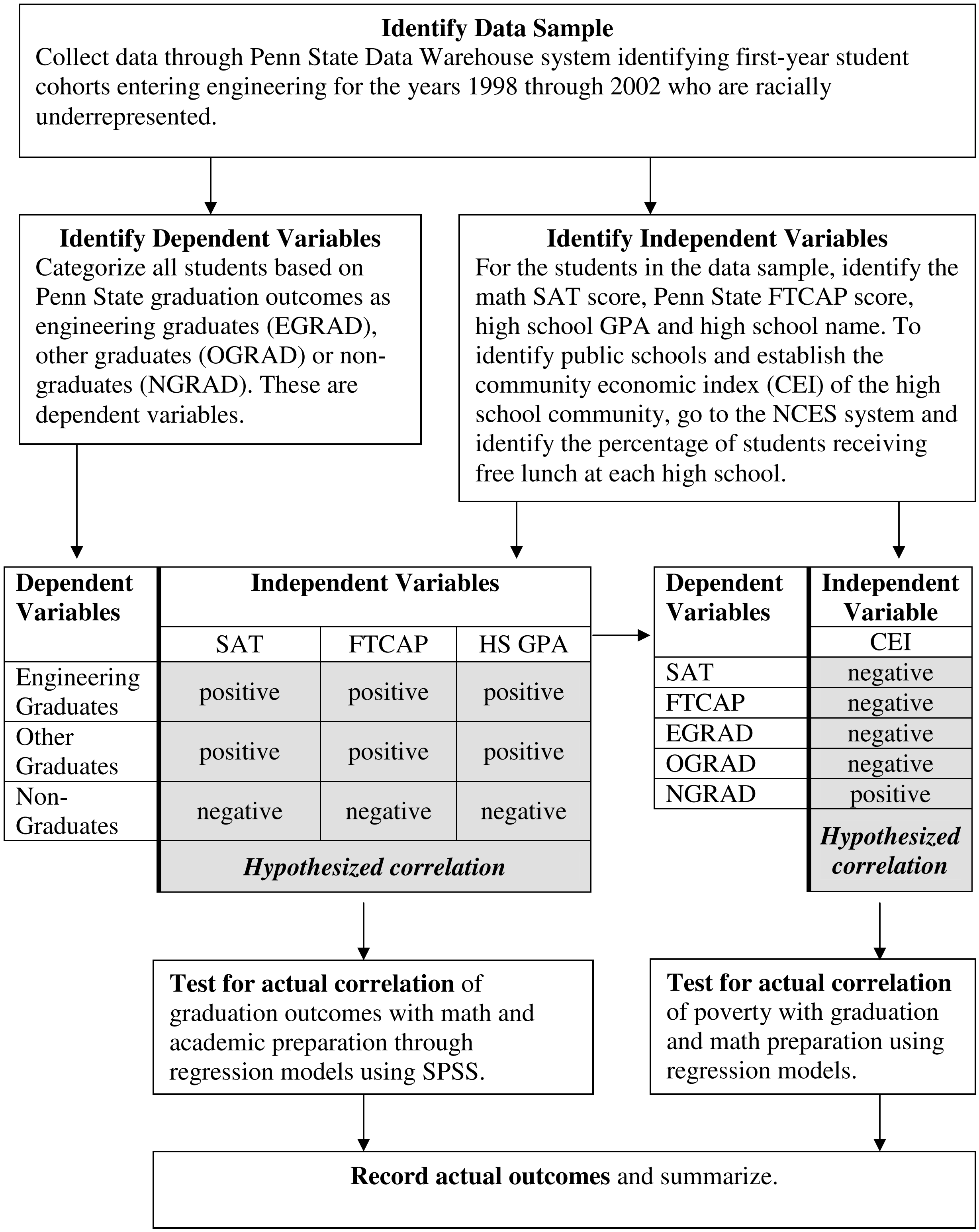

Figure 3.1. Flowchart of data collection process and analysis.

Target Population

The target population consisted of African American and Hispanic American undergraduate engineering students who began and graduated from engineering institutions ranked among the top 25 according to *U.S News and World Report*. *U.S. News* selected these institutions based on research dollars, faculty, facilities, and technological discovery. Engineering colleges listed were recognized as those that have set the highest national standard for engineering training and research. In a typical year, the total underrepresented enrollments for these institutions were approximately 9,000 annually. The College of Engineering at The Pennsylvania State University (Penn State) was counted among these colleges and was ranked at 17 in 2008 (*U.S News and World Report*, 2008).

Data Collection

Data were obtained from the official long-term student records of the Pennsylvania State University stored in the Penn State database, Data Warehouse, and the National Center for Education Statistics (NCES) system through the U.S. Department of Education. Data Warehouse is a collection of student data that tracks students from admissions through graduation. Data are compiled on a continuous basis. Information utilized for this dissertation included date of admission, race, high school attended, high school GPA, SAT math scores, FTCAP scores indicating calculus preparation, and graduation date (Appendices A.1 and A.2). The NCES system provided the percentage of students at high schools receiving free lunch, indirectly identifying communities with high percentages of low-income families with high school students (Appendices B.1 and

B.2). It does not indicate all low-income families—only those with high school-aged children. The data sample was taken from Penn State Data Warehouse over a five-year period, recording the composition of five first-year cohorts who began in the years 1998 through 2002, and graduated within five years (or continued enrollment at Penn State). Over a five-year period, this number totaled about 600 first-year students and was a large enough data sample to produce a confidence level of 95% when making inferences to the larger population.

Dependent Variables

In the evaluation of factors affecting the likelihood of graduation with an engineering degree (research questions 1 and 2), the dependent variables examined in this portion of the dissertation included: graduates with engineering degrees (EGRADS), graduates with other degrees (OGRADS) and non-graduates who did not complete degrees (NGRADS). Regardless of outcome, all students begin in the first year with an intended major of engineering. This dissertation did not include transfer students or others changing majors to enter engineering after the first year.

In the evaluation of the correlation of the high school community economic index with math preparation and college graduation outcomes (research questions 3 and 4), the dependent variables were the mean SAT math score, the mean FTCAP score, and graduation outcomes (EGRADS, OGRADS, NGRADS).

Independent Variables

To study the factors affecting the likelihood of graduation with an engineering degree, the independent variables included SAT score, high school GPA and FTCAP score which measures calculus readiness. The math SAT score is a number ranging from a low of 200 to a high of 800. The high school GPAs of all students recorded in the Data Warehouse have been standardized to a scale ranging from 0 to 4.33. The FTCAP score is a number ranging from 0, indicating little math preparation, to 35, indicating calculus readiness.

For study of the correlation between community economics, math preparation and graduation outcomes, the independent variable was the CEI for local areas where students attended specific high schools. This number is a percentage derived from the total number of students whose families qualify for free and reduced cost lunch divided by the total number in the student body population of a given high school. As an example, a CEI score of 3% indicates that the high school is located in a community where most families are not at the poverty level since only 3 out of 100 qualify for free lunch. A score of 75% indicates that most families in that community (75 out of 100) cannot afford to buy lunch, and consequently cannot contribute substantially to the local tax base that assists the state and federal government in funding the school. Each of these items and their values are summarized in Table 3.1.

Table 3.1

Summary of Variable Names, Values and Labels

Variable Name	Variable Label	Values and Value Label
EGRAD	Engineering graduate	Nominal-dummy code 1
OGRAD	Other graduate	Nominal-dummy code 2
NGRAD	Non-graduate	Nominal-dummy code 3
CEI	Community economic index	Percentage from 1 to 100
GPA	High school grade point average	Number from 0 to 4.33
FTCAP	Math (calculus) readiness level	Number from 0 to 35
SAT MATH	SAT Math score	Number from 200 to 800

Data Analysis

Data analysis was accomplished using SPSS statistical software. Procedures included descriptive statistics (means, standard deviation and percentages) and as the variables were compared for graduate outcomes, math preparation and the community economic index. Analysis of variance showed the correlation between math preparation and the likelihood of graduation in engineering, as well as the correlation between the community economic index, high school math preparation and the likelihood of college graduation, regardless of major. Data analysis for each research question is shown in Table 3.2.

Table 3.2

Research Questions and Proposed Data Analysis Procedures for each Question

Research Question	Independent Variables	Type of Data	Analysis Technique
1. Is there a significant difference between the high school math and academic preparation (high school GPA, SAT score and FTCAP score) of those students who start in engineering and graduate in engineering, and those who start in engineering and do not graduate at all? What is the correlation between math preparation and the likelihood of graduation in engineering?	SAT GPA FTCAP	Ratio/Interval	Descriptive Statistics, Nominal Regression Model
2. Is there a significant difference in the high school math and academic preparation (high school GPA, SAT score and FTCAP score) of those students who start in engineering and graduate in engineering, and those who start in engineering and graduate with other degrees? What is the correlation between math and academic preparation and the likelihood of graduation in other majors?	SAT GPA FTCAP	Ratio/Interval	Descriptive Statistics, Nominal Regression Model
3. For students who begin in engineering, what is the correlation between the high school community economic index (CEI) and the following math and academic indicators: SAT score, FTCAP math score, high school GPA?	CEI	Ratio	Descriptive Statistics, Nominal Regression Model
4. For students who begin in engineering, what is the correlation between the high school community economic index (CEI) and the likelihood of the following graduation outcomes: graduation in engineering, graduation regardless of major, non-graduation?	CEI	Ratio	Descriptive Statistics, Nominal Regression Model

Summary

Upon completion of this study, final data results showed that economic factors play a significant role in the graduation of African American and Hispanic American engineers from the nation's top 25 engineering colleges. This is important because it could suggest that the strategic placement of economic resources at the secondary educational level could increase numbers of professional engineers graduating in the future. Strategic economic areas identified by this study would be: increased disposable income of students families, increased funding for high schools from which engineers are expected graduate, increased math and science resources to ensure that every capable student has access to the highest level of math available, increased exposure to SAT preparation and resource information, and a high school GPA that is truly reflective of the student's technological capabilities.

Chapter 4

RESEARCH RESULTS

The purpose of this dissertation was to examine the relationship of four independent variables that were in place after high school graduation for African American and Hispanic American engineering students, and the correlation of these variables with college graduation outcomes five years later. These factors included Scholastic Aptitude Test (SAT) math scores, calculus preparation level as identified through the Penn State First-Year Testing, Counseling and Advising Program (FTCAP) score, high school grade point average (GPA), and the community economic index of the public high school community (CEI—which indicated the percentage of students qualifying for free or reduced cost lunch). Graduation outcomes were defined as engineering graduate, other graduate or non-graduate.

Research Questions

This dissertation involved four research questions:

1 Is there a significant difference between the high school math and academic preparation (high school GPA, SAT score and FTCAP score) of those students who start in engineering and graduate in engineering, and those who start in engineering and do not graduate at all? What is the correlation between math preparation and the likelihood of graduation in engineering?

2 Is there a significant difference in the high school math and academic preparation (high school GPA, SAT score and FTCAP score) of those students who start in

engineering and graduate in engineering, and those who start in engineering and graduate with other degrees? What is the correlation between math and academic preparation and the likelihood of graduation in other majors?

3 For students who begin in engineering, what is the correlation between the high school CEI and the following math and academic indicators: SAT score, FTCAP math score, high school GPA?

4 For students who begin in engineering, what is the correlation between the high school CEI (poverty level) and the likelihood of the following graduation outcomes: graduation in engineering, graduation regardless of major, non-graduation?

Data Collection Overview

Data were obtained from the official long-term student records of the Pennsylvania State University stored in the Penn State database, Data Warehouse, and the National Center for Education Statistics (NCES) system through the U.S. Department of Education. Data Warehouse is a collection of student data that tracks students from admissions through graduation. Information utilized for this dissertation included date of admission, race, high school attended, high school GPA, SAT math scores, FTCAP scores indicating calculus preparation, and graduation date. Information that is available on a typical Data Warehouse screen accessible to engineering is shown in Appendix A.1.

The NCES system provided the percentage of students at high schools receiving free lunch, indirectly identifying communities with high percentages of low-income families with high school students. The NCES School Search Tool is shown in Appendix

B.1. An example of the information this tool yields is shown in Appendix B.2. In many areas, the poverty rate changes over time. To compensate for this, the NCES Build-a Table tool was used to identify the percentage of students receiving free lunch in a given year. For example, if Student A completed high school in 1998, the free lunch indicator for 1998 (or the nearest year) was used. An example of information provided by the Build-a-Table tool is shown in Appendix B.3. As a result, 433 out of 504 (86%) of the CEI indicators in this dissertation are associated with the year that the student was actually in high school. Current 2009 data was used for 70 school CEI indicators (14%) which did not have information available for earlier years.

The data sample that was taken from Penn State Data Warehouse included five first-year cohorts of African American and Hispanic American students who began in the years 1998 through 2002, and graduation outcomes five years later. Over a 5-year period, this number totaled about 723 first-year students and was a large enough data sample to produce a confidence level of 95% when making inferences to the larger population of underrepresented engineering students attending the top technical research institutions in the U.S. This dissertation evaluated students who enrolled initially seeking bachelor of science degrees in engineering. The evaluation criteria was based on recorded SAT scores, FTCAP scores, high school GPA and CEI for each student. Students who did not fit these criteria were removed from the data set.

Following are those who were eliminated from the original data set of 723 students: 46 students who entered engineering seeking 2-year technical degrees, 169 students who attended schools with no record of free lunch provision (private schools, foreign schools or unlisted high school credentials), and 5 students who had no high school GPA, SAT score or FTCAP score listed. The final number in the research sample was 504. Although there were implications for the larger population of underrepresented students attending top engineering research institutions, for this dissertation, the symbol *N* represented this entire group (*N*=504) while *n* represented sample subgroups of this cohort. A sample of this final data set is shown in Appendix A.2. The demographics of the group are shown in Table 4.1. Demographics include counts and percentages in the categories of race, enrollment year, graduation outcomes, GPA ranges, FTCAP and SAT math score ranges, and CEI ranges.

Statistical review revealed that the distribution of FTCAP scores, SAT scores and GPAs were normal. The CEI, however, had a skewness of 0.870. The recommended correction (Tabachnick and Fidell, 2007) was to use the square root of the variable. The square root of the CEI produced a normal distribution with a skewness of 0.156. Therefore, this variable was used to indicate the community economic level in statistical calculations. (See box plots in Figure 4.1.)

Descriptive statistics of the entire group (*N*=504) are shown in Table 4.2. The group mean SAT math score was 554.28, the mean FTCAP score was 14.92, and the mean GPA was 3.34. Descriptive statistics for those who became engineering graduates, other graduates and non-graduates are shown in Table 4.3. Immediately visible is the difference in math and academic preparation for each group. Engineering graduates had the highest mean scores for SAT, GPA, and FTCAP, with the lowest mean CEI. The significance of these differences between the groups was further determined through several regression models.

Table 4.1

Demographic Profile of Data Sample

Demographic (N=504)	Count	Percentage
Race		
African American	276	54.8%
Hispanic	228	45.2%
Total	504	100.0%
Enrollment Year		
1998-99	93	18.5%
1999-2000	93	18.5%
2000-2001	121	24.0%
2001-2002	90	17.9%
2002-2003	107	21.2%
Total	504	100.0%
Graduation Outcomes		
Engineering Graduates	145	28.8%
Other Graduates	135	26.8%
Non-graduates	224	44.4%
Total	504	100.0%
GPA Ranges		
2.00-2.49	19	3.8%
2.50-2.99	118	23.4%
3.00-3.49	153	30.4%
3.50-3.99	161	31.9%
4.00-4.33	53	10.5%
Total	504	100.0%
FTCAP Math Score Ranges		
0-9	162	32.1%
10-19	191	37.9%
20-29	127	25.2%
30-35	24	4.8%
Total	504	100.0%

Table 4.1 (continued)

Demographic Profile of Data Sample

Demographic (*N* =504)	Count	Percentage
SAT Math Score Ranges		
200-300	2	0.4%
301-400	28	5.6%
401-500	121	24.0%
501-600	191	37.9%
601-700	136	27.0%
701-800	26	5.2%
Total	504	100.0%
Community Economic Index		
0.00 - 25.00%	248	49.2%
25.01 - 50.00%	146	29.0%
50.01 - 75.00%	66	13.1%
75.01 - 100%	44	8.7%
Total	504	100.0%

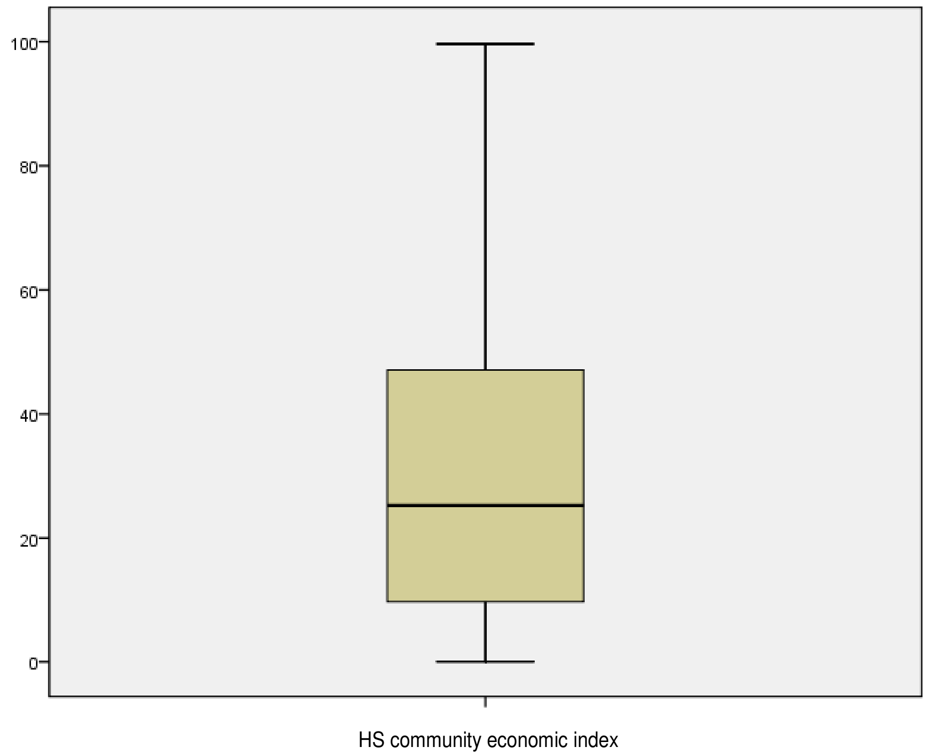

Figure 4.1. Box plot of the community economic index.

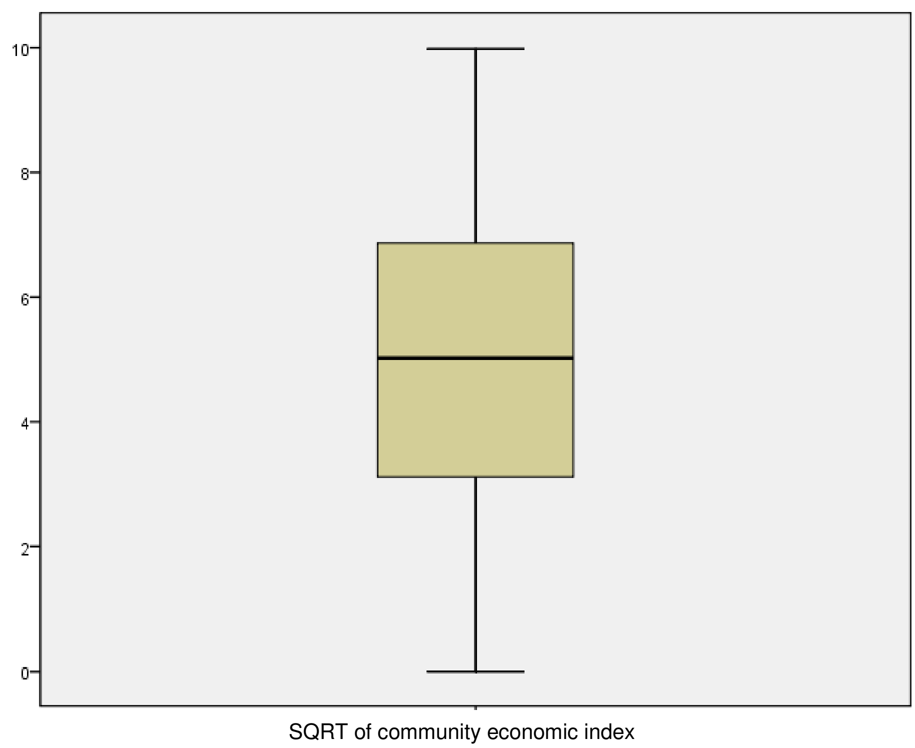

Figure 4.2. Box plot of the square root of the community economic index.

Table 4.2

Descriptive Statistics for All Students

Variable	*N*	Mean	*SE* Mean	*SD*	Minimum	Median	Maximum
High School GPA	504	3.34	0.02	0.50	2.04	3.38	4.33
SAT Math Score	504	554.28	4.26	95.63	200.00	560.00	800.00
FTCAP Math Score	504	14.92	0.46	10.22	1.00	13.00	35.00
Community Economic Index (Sqrt)	504	5.02	0.11	2.38	0.00	5.02	9.98

Table 4.3

Descriptive Statistics for each Graduation Outcome

Variables	*N*	Mean	*SE* Mean	*SD*	Minimum	Median	Maximum
Engineering Graduates							
High School GPA	145	3.61	0.04	0.44	2.42	3.64	4.33
SAT Math Score	145	605.00	6.27	75.47	420.00	610.00	791.00
FTCAP Math Score	145	19.28	0.59	7.16	2.00	20.00	34.00
CEI (Sqrt)	145	4.49	0.18	2.14	0.00	4.37	9.59
Other Graduates							
High School GPA	135	3.30	0.04	0.46	2.45	3.28	4.33
SAT Math Score	135	537.00	8.22	95.21	320.00	535.00	800.00
FTCAP Math Score	135	13.17	0.92	10.68	1.00	11.00	34.00
CEI (Sqrt)	135	4.93	0.21	2.48	0.00	5.02	9.98
Non-graduates							
High School GPA	224	3.20	0.03	0.48	2.04	3.20	4.33
SAT Math Score	224	529.00	6.33	94.96	200.00	540.00	770.00
FTCAP Math Score	224	13.09	0.72	10.82	1.00	12.00	33.00
CEI (Sqrt)	224	5.41	0.16	2.41	0.00	5.31	9.78

Statistical Results

The research questions were intended to examine academic influences on graduation outcomes (research questions 1 and 2), and the affects of community economic conditions on academic preparation and graduation outcomes (research questions 3 and 4). Additional statistics were calculated to see if graduation outcomes could be predicted by math scores, GPA or CEI indicators, or a combination of these variables. Final results were compared to earlier hypotheses.

Academic Preparation and Graduation Outcomes

Research question 1 addressed the academic preparation of engineering graduates as compared to non-graduates. A nominal regression model was run with engineering graduates as the reference group. The likelihood of non-graduation was calculated relative to graduation in engineering. The results are shown in Table 4.4. Compared to engineering graduates, the likelihood of non-graduation was negatively correlated with the SAT score (r = -.397), FTCAP (r = -.308) and GPA (r = -.392) with p <.001 in all cases. This would suggest that the higher the scores are, the less likely a student is to be a non-graduate (and the more likely a student is to be an engineering graduate).

Research question 2 focused on the comparison of the academic preparation of engineering graduates versus other graduates. A nominal regression model was run with engineering graduates as the reference group. The likelihood of graduating in other majors was calculated relative to graduation in engineering. The results are shown in Table 4.5. Compared to engineering graduates, the likelihood of graduating in other majors was negatively correlated with math and academic preparation indicate by the

Table 4.4

Correlations of Academic Preparation, Community Economic Index, and Likelihood of Non-graduation versus Graduation in Engineering (N=369)

	HS GPA	SAT Math	FTCAP Math	Sqrt CEI	Non-graduation
	r	*r*	*r*	*r*	*r pt. biserial*
HS GPA					
Pearson Correlation	1.000	0.349	0.410	-0.082	-0.392
Sig. (2 tailed)	_	0.000	0.000	0.115	0.000
SAT Math					
Pearson Correlation		1.000	0.576	-0.392	-0.397
Sig. (2 tailed)		_	0.000	0.000	0.000
FTCAP Math					
Pearson Correlation			1.000	-0.327	-0.308
Sig. (2 tailed)			_	0.000	0.000
Sqrt CEI					
Pearson Correlation				1.000	0.196
Sig. (2 tailed)				_	0.000
Non-graduation					
Pearson Correlation					1.000
Sig. (2 tailed)					_

Table 4.5

Correlations of Academic Preparation, Community Economic Index, and Likelihood of Graduation in Another Major versus Graduation in Engineering (N=280)

	HS GPA	SAT Math	FTCAP Math	Sqrt CEI	Graduation in Other Majors
	r	*r*	*r*	*r*	*r pt. biserial*
HS GPA					
Pearson Correlation	1.000	0.421	0.374	-0.045	-0.329
Sig. (2 tailed)	_	0.000	0.000	0.450	0.000
SAT Math					
Pearson Correlation		1.000	0.722	-0.305	-0.378
Sig. (2 tailed)		_	0.000	0.000	0.000
FTCAP Math					
Pearson Correlation			1.000	-0.282	-0.328
Sig. (2 tailed)			_	0.000	0.000
Sqrt CEI					
Pearson Correlation				1.000	0.094
Sig. (2 tailed)				_	0.118
Non-graduation					
Pearson Correlation					1.000
Sig. (2 tailed)					_

SAT score (r = -0.378), FTCAP (r = -0.328) and GPA (r = -0.329) with p<.001 in all cases. This would suggest that the higher that these scores are, the less likely a student is to graduate in a non-engineering major (and the more likely the student is to graduate in an engineering major).

Correlations of the Community Economic Index

Research question 3 focused on the correlation between the community economic level (poverty) and academic preparation. Table 4.4 shows the correlation of the CEI with SAT, FTCAP and GPA for non-graduates versus engineering graduates. Although community poverty was not significantly correlated with high school cumulative GPA, it was significantly correlated (p< .001) with both the SAT (r = -0.394) and FTCAP math scores (r = -0.327). Table 4.5 shows the correlation of the CEI with SAT, FTCAP and GPA for graduates of other majors versus engineering graduates. Although the CEI was not significantly correlated with high school cumulative GPA, once again, it was significantly correlated (p< .001) with both the SAT (r = -0.305) and FTCAP (r = -0.282) math scores. This would suggest that the higher the poverty level of the high school community, the lower the math scores of high school students.

Research question 4, focused on the correlation between community poverty and graduation outcomes. The nominal regression model using engineering graduates as the reference group showed that the CEI does not significantly affect the likelihood of graduation major (engineering versus other majors, Table 4.5). On the other hand, the

CEI is correlated positively with the likelihood of non-graduation when compared to graduation in engineering (r = 0.196, p=.001) shown in Table 4.4.

Outcome Prediction Based on Multinomial Logistic Regression

To what degree can academic preparation and the poverty predict the likelihood of certain graduation outcomes? A multinomial logistic regression showed that the combined effect of GPA, FTCAP, SAT and the CEI does explain or predict some percentage of the variance in graduation outcome and is detailed in Tables 4.6, 4.7, and 4.8. The Cox and Snell pseudo R^2 (Table 4.6) indicates that these combined factors explain 75.6% of the variance in graduation outcomes. Table 4.7 shows that each of the four factors significantly ($p \leq$ .001) influenced differences in graduation outcomes. Table 4.8 identifies actual counts in each category of outcome predictions. Table 4.8 also shows that the graduation outcomes were predicted with an overall accuracy 85.5% based on the combined effect of GPA, FTCAP, SAT and the CEI. When graduation outcomes are reviewed separately, the likelihood of engineering graduation was predicted with an accuracy of 89.6%, non-graduation at was predicted at 88.0% and the likelihood of graduation in other majors was predicted at 76.9%.

Multinomial logistic regressions were also run on several combinations of the four predictor variables, GPA, FTCAP, SAT and CEI. The accuracy of predicted graduation outcomes based on high school GPA alone was 65.4%. The accuracy of predicted graduation outcomes based on the combined effect of high school GPA and SAT was 75.5%. The accuracy of predicted graduation outcomes based on the combined effect of high school GPA, SAT and FTCAP math scores was 83.5%.

Table 4.6

Variance in Graduation Outcomes Explained by Given Predictors

	Pseudo R-Square
Cox and Snell	.765
Nagelkerke	.866
McFadden	.676

Table 4.7

Overall Predictor Effects

	Model Fitting Criteria	Likelihood Ratio Tests		
Effect	-2 Log Likelihood of Reduced Model	Chi-Square	df	Sig.
Intercept	349.30	.000	0	.
HS_GPA	787.99	438.72	310	.000
SAT_Math	537.64	188.39	124	.000
FTCAP_Math	486.10	136.81	66	.000
R_Sqrt_CEI	373.40	24.096	6	.001

Table 4.8

Outcomes Predicted by Academic Preparation and Community Economic Index

	Predicted			
Observed	Eng Grad	Non Grad	Other Grad	Percent Correct
Eng Grad	129	8	7	89.6%
Non Grad	11	198	16	88.0%
Other Grad	9	22	103	76.9%
Overall Percentage	29.6%	45.3%	25.0%	85.5%

The log odds ratios measuring the effect of all four variables (SAT, FTCAP, GPA, and CEI) were calculated for the following graduation outcomes: engineering graduation versus non-graduation, engineering graduation versus graduation in other majors, and non-graduation versus graduation in any major. (By definition, if Exp(B) =1.000, this suggests that there is no significant effect.) Each of the outcome comparisons are reviewed below.

When evaluating the likelihood of graduation in engineering versus non-graduation, the log odds ratio for the high school GPA was Exp(B)=3.343. This suggests that for each unit (grade point) increase of GPA, the log odds of graduating in engineering (versus non-graduation) increases by 3.34 times. HS GPA was the most significant factor (r=.05). The SAT and CEI were very mildly significant in affecting the graduation outcome with Exp(B) for SAT being 1.006 and Exp(B) at 0.904. The FTCAP score did not affect the graduation outcome significantly.

When evaluating the likelihood of graduation in other majors versus graduation in engineering, the log odds ratio for the high school GPA was Exp(B)=0.495. This suggests that for each unit (grade point) decrease of HS GPA, the log odds of graduating in another major (versus graduation in engineering) increases by 0.495 times. Here GPA was the only significant factor (r=.05) affecting graduation. The SAT, CEI and FTCAP did not affect the graduation outcome significantly.

When evaluating the likelihood of graduation in any major (engineering or other) versus non-graduation, the log odds ratio for the high school GPA was Exp(B)=2.001. This suggests that for each unit (grade point) increase of HS GPA, the log odds of graduating from college (versus non-graduation) increases by about two times. Again, GPA was the most significant factor (*r*=.05) while the SAT and CEI were very mildly significant in affecting the graduation outcome with Exp(B) for SAT being 1.003 and Exp(B) at 0.913. The FTCAP score did not affect the graduation outcome significantly.

Hypotheses Testing Results

Each of the four research questions, hypothesis and findings were reviewed and summarized in this section.

Research Questions 1 and 2, Hypotheses and Findings

Research question 1 was: Is there a significant difference between the high school math and academic preparation of those students who start in engineering and graduate in engineering, and those who start in engineering and do not graduate at all? What is the correlation between math preparation (high school GPA, SAT score and FTCAP score) and the likelihood of graduation in engineering?

Research question 2 was: Is there a significant difference in the high school math and academic preparation (high school GPA, SAT score and FTCAP score) of those students who start in engineering and graduate in engineering, and those who start in engineering and graduate with other degrees? What is the correlation between math and academic preparation and the likelihood of graduation in other majors?

The hypotheses for research questions 1 and 2 was as follows: Because math success is critical in the engineering major, it was expected that the math preparation (SAT and FTCAP scores) of graduating engineers would be higher than that of those who graduate in non-technical fields as well as those who do not graduate (Fleming, 2000; Gilmer, 2007; Guthrie, 1992; Russell & Atwater, 2005). Several studies positively correlate engineering academic success with precollege math preparation whether through high school or summer bridge programs preceding the first semester in a university technical program. It was also hypothesized that high school GPA would not be significantly different for graduates and non-graduates since all are generally accepted into engineering with GPA as a heavily weighted factor.

Findings for the hypotheses regarding math preparation (SAT and FTCAP scores) were substantiated in this author's dissertation indicating that those students with higher math scores were significantly more likely to graduate in engineering. For the GPA, however, the hypothesis was not substantiated, but rather, the high school GPA followed the trend of the SAT and FTCAP scores such that engineering graduates were significantly more likely to have a higher GPA than non-graduates and graduates of other majors.

Research Question 3, Hypotheses and Findings

Research question 3 was: For students who begin in engineering, what is the correlation between the community economic index (CEI) and the following math and academic indicators: SAT score, FTCAP math score, high school GPA?

In the original hypothesis, findings for research question 3 were expected show that math preparation was negatively correlated with community economic index, such that a student from a community with a higher economic index (higher poverty level) is more likely to have lower SAT and FTCAP math scores. This could indicate a lower availability of local funding resources for the high school. This correlation was supported in this dissertation.

Research Question 4, Hypotheses and Findings

Research question 4 was: For students who begin in engineering, what is the correlation between the CEI and the likelihood of the following graduation outcomes: graduation in engineering, graduation regardless of major, non-graduation?

The hypothesis for research question 4 was that a negative correlation was expected between the community economic index (CEI) and the graduation rates of engineers versus non-engineers. The findings however, did not support this theory. There was no significant difference in the CEI and the likelihood of a specific graduation major. A positive correlation was expected between the community economic index and the likelihood of non-graduation of those beginning in engineering. This hypothesis was substantiated. The CEI was positively correlated with non-graduation.

Chapter 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

Increasing the number of engineers in the U.S. is a national challenge. One of the primary strategies employed to address this challenge is to recruit from larger populations that are not proportionately represented in the profession. This would include racially underrepresented groups such as African Americans and Hispanic Americans. For engineers, one of the first professional development milestones to reach is the attainment of the engineering bachelor degree. The path to degree completion involves high school faculty, university officials, technical employers who provide math and academic preparation, funding opportunities, and professional development opportunities. All of these elements are designed to encourage students to persist through to degree completion. Upon degree completion, the engineer enters the profession. The overall purpose of this dissertation was to examine the relationships between math preparation and poverty levels that were in place prior to entering college, and college graduation outcomes five years later. College graduation outcomes were categorized as graduation in engineering, graduation in another major, and non-graduation.

The study was conducted using secondary data from the official long-term student records of the Pennsylvania State University stored in the Penn State database, Data Warehouse, and the National Center for Education Statistics (NCES) system through the U.S. Department of Education. The data set was derived from five cohorts of African American and Hispanic students entering the Penn State College of Engineering in the five years spanning from 1998 through 2002. Academic information, poverty indicators and graduation outcomes were evaluated. Correlations and outcome predictors were established.

Nominal regression, along with descriptive statistics, was the primary research technique used to answer the research questions. Research questions addressed two areas: the correlation of academic preparation to graduation outcomes, and the correlation of poverty with academic preparation and graduation outcomes. Overall, it was found that academic and math preparation is significantly positively correlated with graduation in engineering. The poverty level of the high school community was significantly positively correlated with non-graduation, but negatively correlated with math preparation. Multinomial logistic regression showed that graduation outcomes are influenced and can be predicted by the combined effect of math scores, academic preparation, and the community economic index.

The first four chapters present an overview of the problem, research questions, review of related literature, methodology utilized to complete the study and the result of data analysis. This final chapter will discuss these findings in the context of related literature and will review conclusions recommendations.

If math preparation can be positively correlated with the graduation of underrepresented engineers, yet negatively correlated with the community poverty level, it would appear that the improvement of these two very tangible factors (poverty and math preparation) could yield more engineers for industry. The results of this dissertation are reflected in a simplified flowchart in Figure 5.1 showing the relationship between poverty, math preparation and engineering graduation.

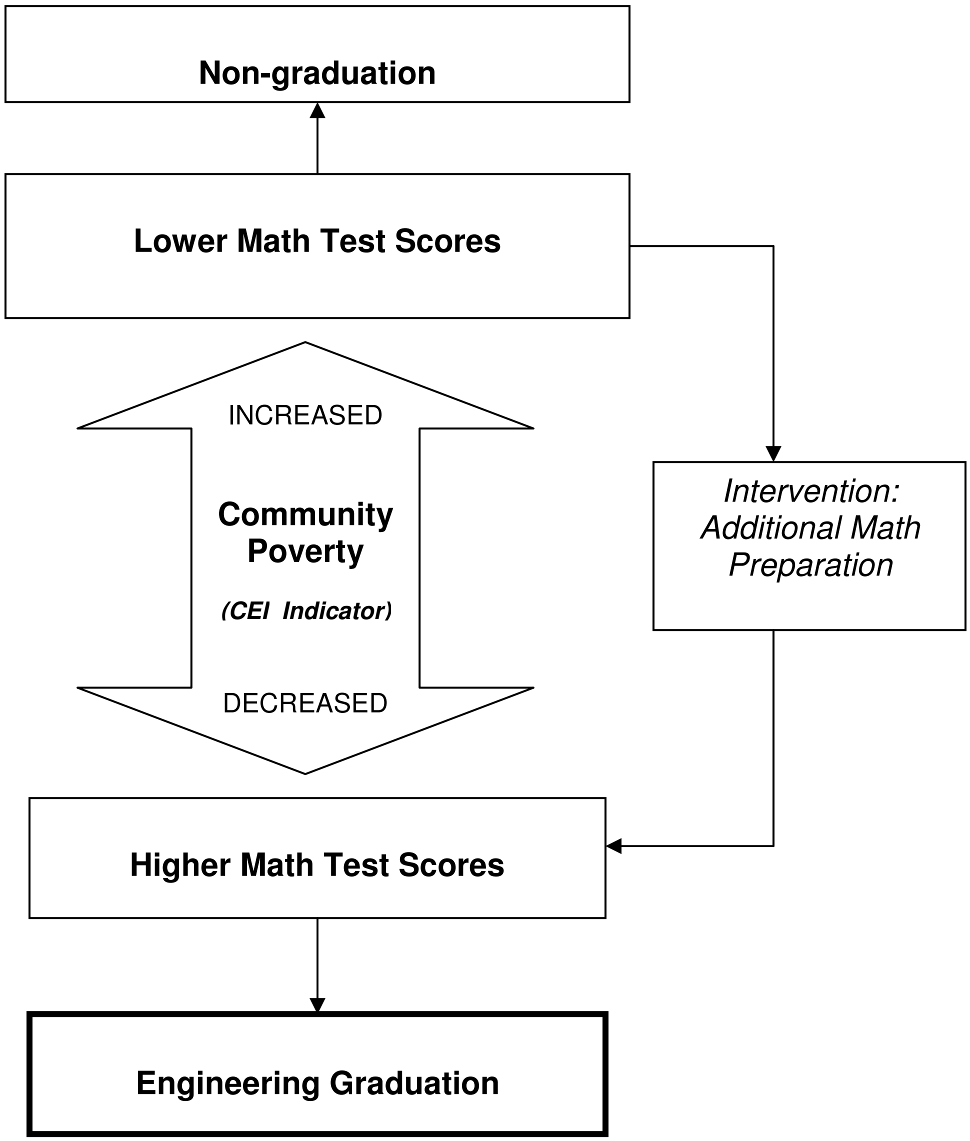

Figure 5.1. Relationship between poverty, math and engineering graduation.

Analysis of Academic Preparation and Graduation Outcomes

Two of the academic components evaluated included the SAT and FTCAP math scores, both of which are indicators of math preparation. This study revealed that each of these factors are correlated positively with the likelihood of graduation in engineering. The correlation of math and the likelihood of graduation is supported in several ways through the literature. The Meyerhoff Program is a multicultural retention program designed for students who enter college majoring in technical fields with a High School GPA over 3.5. This program has a 90 percent college graduation rate. The success of the Meyerhoff retention program at University of Maryland is attributed to required math preparation at the pre-college level among other factors (Maton, Hrabowski, & Schmitt, 2000).

The GPA is a reflection the overall high school academic performance, and is not necessarily reflective of math preparation. It is more reflective of general study skills and persistence (Grandy, 1995). Yet, it too is positively correlated with the likelihood of graduation in engineering. This finding supports literature contending that students who arrive with excellent high school credentials but poor math test scores can still become engineers if they have the persistence to follow through with a math review intervention (Guthrie, 1992).

Analysis of the Correlation of Poverty with Academic Preparation and Graduation

Poverty is an interesting variable. It is defined in this dissertation through the community economic index (CEI) which is a finite indicator of the percentage of free and reduced lunch recipients at a given high school, yet it has many other implications. It does not reflect a particular student, but rather the poverty level of the community, and the potential tax base available to fund the school. Originally, this author assumed a direct correlation between community poverty and engineering graduation, however, there is little difference in community poverty level based on graduation major. Poverty is more directly correlated with non-graduation.

A community in poverty implies that there is limited funding designated for high schools. This affects class size, teacher effectiveness, varied perceptions regarding the need for math education through the twelfth grade, and variations in quality of instructional resources (The Campaign for Fiscal Equity, 2003; The Education Trust, 2003). Although this dissertation addressed math preparation, it is conceivable that a school in an impoverished area would be lacking in adequate preparation for many subjects.

Excellent math preparation means that there are more teachers trained in math and science education, smaller classroom sizes, provision of science resources such as laboratory equipment and text books (Cech, 2007). In the most effective environments, math preparation is defined as a requirement rather than an option (Massachusetts Department of Education, 2006).

Poverty does not have a significant correlation with GPA. This would mean that a student from a wealthy school district is as likely to get good grades as a student from an impoverished district. The implication is that both students were persistent in all academic work presented, while the SAT scores may show that both students were presented with different information during the high school years.

Graduation in engineering as compared to graduating in any other major has no significant correlation with community poverty while graduation in engineering as opposed to non-graduation it has a significant correlation with community poverty (r=0.196) shown in Table 4.4. Graduation in engineering (versus non-graduation or graduation in other majors) has a stronger correlation with math preparation (SAT and FTCAP) as shown in Tables 4.4 and 4.5. Compared to engineering graduates, the likelihood of non-graduation was negatively correlated with the SAT score (r = -0.397), FTCAP (r = -0.308) with p <.001. This would suggest that the higher the scores are, the less likely a student is to be a non-graduate (and the more likely a student is to be an engineering graduate). Poverty has its strongest connection with engineering graduation through its effect on math preparation.

.

<u>Implications for Policy Makers, Government and Universities</u>

The research results of this dissertation present several opportunities for modifying the current educational system, and re-evaluating where resources should be distributed. If more engineers are to evolve, math preparation at the K-12 level is a must. Math-based retention programming is critical for retaining first year students in engineering. Many diversity retention programs, including those at Penn State, are funded largely through corporate donors. Should these programs be systematically funded through the government and the university? Poverty implies a need for educational funding and renewable scholarships. This is a challenge to both university officials and government leaders with the rising annual cost of tuition. Although every challenge is not addressed in this dissertation, these two modifications could make a significant difference in the numbers of engineers who graduate.

Contributions

The contribution of this dissertation to the larger body of knowledge is that it identifies tangible variables that can be tied to engineering graduation outcomes, going beyond first and second year retention methods. Although the positive correlation of math preparation and retention in engineering has been extensively supported (Kezar, 2000; Lang, 2001; Maton, Hrabowski, & Schmitt, 2000; Morrison & Williams, 1993; Schrader & Brown, 2008; Tinto & Love, 1995), this dissertation directly associates community poverty with math preparation of high school students. The implication is that students in poorer communities have a lesser chance of becoming an engineer, an occupation with an average starting income that could propel an engineering graduate into the middle class. This dissertation provides additional evidence supporting the philosophy of increasing funding for pre-college math preparation and college math-based retention programming in order to yield more technical professionals in the future. This study successfully tested predictors of engineering graduation outcomes that are not race based, but rather have to do with providing improvements to the education system that that are correlated with economic class.

Limitations

The limitations of this dissertation are several. When examining the connection from community poverty to math preparation to graduation outcome, it becomes clear that each of these have evolved under unique circumstances for each student. Community poverty has implications that go beyond free or reduced lunch at a given high school, or the quality of math programming at that school. The association of poverty with non-graduation could also be an indicator of students who did not receive enough scholarships or other college funding to continue at Penn State. It is also possible that the student developed a greater personal interest in another subject, regardless of math preparation.

Non-graduation only implies that the student did not graduate from Penn State. Many students leave Penn State due to cost and continue on to become engineers at other institutions. In addition, many students leave due to illness. This data set covers students over a five year period from initial enrollment. Some students identified as non-graduates in this data set may have simply taken longer than 5 years to graduate, and could have become Penn State engineering graduates nonetheless. Non-graduation (or graduation) can also be attributed to the level of participation in the wide range of social programs at Penn State University designed for retention. Non-graduation could be a result of under- or over involvement in social events and organizations. None of these factors were considered in this study.

This dissertation was completed using student who attended public schools. These same factors could yield different results if the data set were attendees of private schools.

Finally, it cannot be assumed that all of the engineering graduates will add to the number of engineering professionals in the U.S. Not all who graduate continue on to become engineering professionals. Some become lawyers, business professionals, doctors, teachers and a wide range of other occupations. This dissertation did not include information regarding the actual occupations that graduating engineers pursue, nor the percentage of engineers who remain in the profession after graduation.

Recommendations for Future Research

As this dissertation was being completed, new research questions developed as the data was examined further. There are a number of areas that warrant additional research. They include:

- Further examination of the community poverty variable
- Evaluation of the differences found between populations
- Development of instruments that provide information regarding the likelihood of graduation
- Evaluation the yields of graduating engineers coming from current math-intensive K-12 programs
- Diversification of data-collection methods

The Poverty Variable

As mention earlier in this dissertation, community poverty is a multifaceted variable with many indictors that extend far beyond the percentage of students receiving free lunch at a given high school. Poverty by definition implies that there is a high need for scholarship funding. In this study, 100 out of 504 students had a community economic index that exceeded 50% (Table 4.1). Among those students, 21 were engineering graduates. Were engineering graduates from poor communities more likely to have received scholarships (or other financial resources) than non-graduates? Were non-graduates from poor communities more likely to have held an outside job, thus losing study time lowering the likelihood of graduation? Scholarships, loans and financial aid awards are unique for each student.

This dissertation evaluated students attending a university where current cost of attendance exceeds $25,000 for in-state students. The cost to non-Pennsylvania residents is higher and tuition costs escalate each year. It would be interesting to note the most widely used method paying for college that was utilized by engineering graduates with high financial need at Penn State, versus less expensive engineering colleges. Are those with lesser college costs more likely to receive awards that cover a higher percentage of the cost? Does addressing this aspect of poverty (related to college costs) lessen the number of non-graduates? All of these questions await further research.

Differences Between Populations

This dissertation evaluated African Americans and Hispanic Americans as a single group based on their underrepresentation in the engineering workforce (Bureau of Labor Statistics, 2007). It is possible that if these groups were evaluated separately, there could be problems that are more pronounced in one group over the other such as levels of community poverty, GPA, math test scores, likelihood of participation in math review, and likelihood of graduation or non-graduation. Originally, Native American students were to be included in this study, however, there were so few (less than 15 enrolling first-year students out of 500, with engineering graduates in single digits) that it could not be assumed that findings for the remainder of the group applied to this group. A separate study reviewing barriers to attaining the engineering degree would have to be designed to focus on Native American students. Research methods used in this dissertation could also be applied to other groups (students attending private schools, women, white males, students of Asian descent, non-traditional students, international students and students attending historically Black colleges and universities (HBCUs), Hispanic serving institutions (HSIs) or tribal colleges). Comparisons might show graduation outcomes of these groups are based on different factors.

Instrument Development for Early Indication of Graduation Likelihood

The multinomial logistical regression identified GPA, SAT, FTCAP and the CEI as having a strong combined influence on graduation outcomes. It is possible that future research could reveal an equation or instrument showing thresholds or overlapping ranges of these variables figures associated with potential graduation outcomes. This could allow early intervention that would positively influence the likelihood of engineering graduation. Such an instrument could provide information to education officials regarding the likelihood of graduation based on high school indicators, and a list of remedies that would improve this likelihood.

Examples of intervention would be additional math preparation, study skills courses, and modifications to the scholarship selection process. Ideally, economic conditions should not be a barrier to career opportunities. This information could also assist in informing students of their potential.

Effectiveness of Math Preparation Programs

Future research could further test the findings of this dissertation that precollege math preparation results in a higher likelihood of graduation in engineering. This dissertation utilized data that targeted students at public schools, however, similar tests could be run comparing public school students to those who attended math-focused programs and math magnet high schools. Future research could also evaluate the graduate outcomes of those students participating in newer programs that are currently intensifying the math preparation of K-12 students such as Project Lead the Way (Cech, 2007) and the State of Massachusetts' requirement for a K-12 engineering curriculum in all schools across the state (Massachusetts Department of Education, 2006). It will be several years before these students graduate from college, however, they would provide data which would determine if indeed there were a higher percentage of engineers emerging from the current incubator. If these pilot programs prove to produce more technical professionals, they would serve as models for future generations.

Diversification of Data-Collection Methods

Finally, this dissertation was based on secondary data. No students were actually contacted, no human information was collected. Therefore, solutions to this problem are incomplete. Diversification of the data-collection methods would yield more insight than is provided here. For example, results of this dissertation showed that math preparation is related to engineering graduation, but what kind of math preparation is most effective? Why did some students with high math scores and low community economic indices poverty ratings not graduate? What is the change agent that made it possible for students from higher poverty situations (with indicators exceeding 75%) or lesser math and academic preparation (SAT math scores below 500 and GPA below 3.0) to graduate in engineering nonetheless? Questionnaires, focus groups, surveys or interviews might indicate new factors that are not included in this study which are correlated with graduation in engineering. Many of these factors can only be established through longitudinal interaction with engineering students, regardless of graduation outcome.

Summary

The U.S. is challenged to produce more engineers to remain globally competitive (Galama & Hosek, 2007). To solve this problem, industry and university leaders have sought to develop professionals from populations that have not been well represented in the profession in the past such as African Americans and Hispanic Americans. This dissertation suggested that access to the profession begins early on the career path with math preparation at the pre-college level and economic resources to fund a college education. For students receiving inadequate math preparation, many technical professions are already out of reach before high school graduation. This dissertation also suggested that math preparation was correlated with the economic income levels of the families in the high school community. If the U.S. is to increase the numbers of domestic engineering professionals, it must invest heavily in an excellent K-12 math education system as a long term strategy. In the short term, the support of math-intensive intervention programming is critical to the retention and graduation of those currently beginning the college engineering curriculum.

In this dissertation, the sample was identified by race, however, the factors that determined their success in math was the community economic index, a non-racial element associated with family incomes in a given local area. At the same time, it has been shown that African American and Hispanic American students are more likely to come from families of lower economic backgrounds (The Education Trust, 2003; Yeung, 2008). When considering these factors, it is possible that the underrepresentation of these groups in engineering is a combination of both race and class, rather than the singular effects of one or the other. (The effect of this combination is another area warranting further study.) As discussed earlier in this chapter, community poverty as related to family income also has implications regarding the need for college scholarships. The most successful math intervention programs include both renewable scholarship funding and math-intensive curriculums (Maton, Hrabowski, & Schmitt, 2000; Persaud & Freeman, 2005). For students with high economic need, both of these factors are equally important in ensuring graduation in engineering and access to the profession.

The ideal solution for increasing the numbers of engineers in the U.S. would be to provide access to all who seek to enter the profession, regardless of economic background. Although the problem is clear, implementation of the solution is not. One way to find answers is to look at the math education models of technical competitors of the U.S. Perhaps other successful models could be modified to assist us.

Consider this author's following analogy regarding reading skills in the U.S. versus math skills: In the U.S., it is expected that all students are capable of reading unless there is a clear learning disability. If a student contends that he or she cannot read or is unable to grasp the skill of reading well, it is widely held that additional hard work is needed such as phonics, tutoring, or increased reading time. Math, however, is viewed more as a gift or a fixed level of ability, rather than a skill that can be continuously learned and improved upon, especially at the higher levels. If a student contends that he or she is unable to do well in math, the typical response is that the student is not gifted with this higher ability level and sometimes should be redirected to focus on other skills. Conversely, if a student does well in math, it is assumed that the student has a gift or additional propensity for math that the others do not have. Whereas few in the U.S. would announce that he or she were never good at reading (even if it were true), it is not uncommon for people to say publically that they are not good at math.

As it regards teaching, U.S. teachers read well. When they teach reading, they teach a topic that they are well versed in. On the other hand, there are not enough U.S. teachers of math, and most have not received specialized training in mathematics (Galama & Hosek, 2007). What is it like to teach a course that without an advanced knowledge of it? If the teacher perceives the course as difficult or vague, how is the topic conveyed to the students?

If we compare what other technically competitive countries are doing regarding math preparation of their students to enlarge the engineering pool, there is a marked difference. Xiaoxia Newton (2007), an education scholar in the U.S. who was raised in China, compared the math and science teaching methods of China to those of the U.S. In China, Newton contended, math was treated similarly to reading in the U.S. in the analogy above. Math excellence was associated with hard work and persistence rather than a presumed fixed level of ability. Persistence is an attribute that anyone can possess, while a fixed ability level is suggests that there is no room for change or growth. Should students contend that they cannot do the math, the answer is: more tutorials, more math problems, more examples to apply. The K-12 math teachers in China focused on only one topic and were not expected to be knowledgeable in all fields. This was especially true at the elementary levels where the foundation of all subjects was established. Students were taught by those who did not perceive their field as difficult or impossible to learn. On the other hand, Newton found that in the U.S., it was acceptable for an elementary teacher to teach with a minimal, general knowledge of several topics. In the U.S., teachers received little time to reflect, to collaborate, to receive professional development. Most of the ime was spent teaching. In China, about 40% of the teachers' time was spent for professional development and working collaboratively to establish the best sequence in which topics should be taught in math, and science to determine the most cohesive curriculum for the students. The results of student math scores for both countries reflect the respective K-12 investment in math education. Students in China and other Asian countries score higher in math than high school students in the U.S. (Asia Society, 2006). Producing more technical professionals in the U.S. could entail modifying how we teach and introduce math and science to children, and learning from other education systems in the world.

If the United States took a different path in the resourcing and implementation of its public education system, this author can only speculate what the national outcomes would be. What would happen if the U.S. chose to use a different model for how it introduced math to students? What if the U.S increased the mathematical training requirement of K-12 teachers who teach math and science? What if the resources of K-12 schools were not contingent upon local economics and taxes, but rather a standardized public education system funded by the federal government. What if no school was permitted to fall below a federal minimum standard for education? Areas with more resources could still add to the educational variety of local schools, however, all public schools could be required to have current text books, safe facilities, science laboratory equipment and libraries, well paid teachers qualified to teach topics assigned, nutritional meal programs, computer access, small classroom sizes, and national curricular goals. What if a college education were affordable and accessible for all who wished to attend (much like the primary and secondary system)? This author speculates that the outcome might not only be more engineers, but more graduates in general and a well informed, more globally competitive citizenry.

REFERENCES

Allen, L. (2001). *An evaluation of Missouri-Rolla minority engineering program: Seven week summer bridge program.* University of Missouri-Columbia, Columbia.

American Society of Engineering Education. (2007). *Engineering college profiles and statistics* [Data File]. Available from the ASEE website http://www.asee.org/publications/profiles/index.cfm#Online_Profiles

Asia Society. (2006). *Math and science in a global age: What the U.S. Can learn form China*. New York, NY: Asia Society

Brazziel, M. E., & Brazziel, W. E. (2001). Factors in decisions of underrepresented minorities to forgo science and engineering doctoral study: A pilot study. *Journal of Science Education and Technology, 10*(3), 273-280.

Bush, G. (2006). State of the Union Address. Available from Whitehouse Website http://www.whitehouse.gov/stateoftheunion/2006/

Callanan, G., & Benzing, C. (2004). Assessing the role of internships in the career-oriented employment of graduating college students. *Education + Training, 46*(2), 82-89

Commission on Professionals in Science and Technology (2008). Science, Engineering and Human Resources Data Base [Data File]. Available from the CPST website http://www.cpst.org/HRDATA/Pages/HRDatabase.cfm

Cech, S. (2007). Engineering a blueprint for success. *Education Week, 27*(5), 26.

Chambers, J. G., Levin, J. D., & Parish, T. B. (2006). Examining the relationship between educational outcomes and gaps in funding: An extension of the New York adequacy study. *Peabody Journal of Education, 81*(2), 1–32.

Engstrom, C., & Tinto, V. (2008). Access without support is not opportunity. *Change: The Magazine of Higher Learning, 40*(1), 46–50.

Fleming, J. (2000). Affirmative action and standardized test scores. *Journal of Negro Education, 69*(1–2), 27–37.

Fleming, J., & Morning, C. (1998). Correlates of the SAT in minority engineering students: An exploratory study. *The Journal of Higher Education, 69*(1), 89.

Florida, R. (2002). *Rise of the creative class*. New York: Basic Books.

Freeman, A. L., & Persaud, A. (2005). *Academic summer enhancement (ASE) program.* Paper presented at the 2005 Women in Engineering Advocates Network and National Association of Multicultural Engineering Program Administrators Joint Conference, Las Vegas, NV.

Galama, T., & Hosek, J. (Eds.). (2007). *Perspectives on U.S. competitiveness in science and technology*. Santa Monica, CA: Rand Corporation.

Georges, A. (1999). Keeping what we've got: The impact of financial aid on minority retention in engineering. *NACME Research Letter, 9*(1).

Gilmer, T. C. (2007). An understanding of the improved grades, retention and graduation rates of STEM majors at the academic investment in math and science (a.i.m.s.) program of Bowling Green State University (BGSU). *Journal of STEM Education: Innovations and Research, 8*(1/2), 1-11.

Good, J. (2000). A promising prospect for minority retention: Students becoming peer mentors. *The Journal of Negro Education, 69*(4), 375.

Grandy, J. (1995). *Persistence in science of high ability minority students: Phase 5, comprehensive data analysis*. Princeton, NJ: Educational Testing Service.
Gratz v. Bollinger, 539 U.S. 244 (2003).
Gray, K. C., & Herr, E. L. (1998). *Workforce education: The basics*. Needham Heights, MA: Allyn & Bacon.
Grief, G. L., Hrabowski, F. A., & Maton, K. I. (2000). African American mothers of academically successful sons: Familial influences and implications for social work. *Children & Schools, 22*(4), 232-246.
Grutter v. Bollinger, 539 U.S. 306 (2003).
Guthrie, L. F. (1992). *Retention and performance of at-risk students in the California state university system. Knowledge brief number 10.* Washington, DC: Office of Educational Research and Improvement.
Hopwood v. Texas, 78 F.3d 932 (1996).
Hu, N. B. (2002). *Measuring the weight of high school GPA and SAT scores with second term GPA to determine admission/financial aid index: A case study.* Paper presented at the Association for Institutional Research, Toronto, Canada.
Institute of Education Sciences. (2007). *National Center for Education Statistics* [Data File]. Available from the Department of Education Website http://nces.ed.gov/globallocator/
Jablin, F. M. (2000). Organizational entry, assimilation, and disengagement/exit. In F. M. Jablin & L. L. Putnam (Eds.), *The new handbook of organizational communication* (pp. 732–818). Thousand Oaks, CA: Sage.
Kezar, A. (2000). Summer bridge programs: Supporting all students. *Educational Research and Improvement Digest, Series EDO-HE-2000-3*).
Kleupfel, G. A. (1994). Developing successful retention programs: An interview with Michael Hovland. *Journal of Developmental Education, 17*(3), 28.
Ku, I., & Plotnick, R. (2003). Do children for welfare families obtain less education? *Demography, 40*(1), 151–170.
Landis, R. (Ed.). (1985). *Improving the retention and graduation of minorities in engineering. Handbook.* New York, NY: National Action Council for Minorities in Engineering, Inc.
Lang, M. (2001). Student retention in higher education: Some conceptual and programmatic perspectives. *Journal of College Student Retention, 2001/2002, 3*(3), 225.
Lederer, E. (2004). The warm body in the math class. *Principal Leadership, 4*(7), 50.
Lerner, R., & Nagai, A. K. (1997). *Racial preferences in Colorado higher education. Racial preferences in undergraduate admissions at the public colleges and universities in Colorado*. Washington, DC: Center for Equal Opportunity.
Levine, K. (2006). Adolescents' conceptions of work: What is learned from different sources during anticipatory socialization? *Journal of Adolescent Research, 21*(6), 647.
Maton, K. I., Hrabowski, F. A., III, & Schmitt, C. L. (2000). African American college students excelling in the sciences: College and postcollege outcomes in the Meyerhoff scholars program. *Journal of Research in Science Teaching, 37*(7), 629–654.

Miloy, C. (2002, Oct. 7). Fine role models but few answers for success. *The Washington Post,* p. B.01.

Moin, L. (2005). Where can we find future K-12 science and math teachers? A search by academic year, discipline, and academic performance level. *Science Education, 89*(6), 980.

Morrison, C., & Williams, L. E. (1993). Minority engineering programs: A case for institutional support. *NACME Research Newsletter, 4*(1).

National Academy of Sciences. (2007). *Rising above the gathering storm: Energizing and employing America for a brighter economic future*. Washington, DC: The National Academies Press.

National Association of Multicultural Engineering Program Advocates (2008). Available from www.namepa.org

Newton, X. (2007). Reflections on math reforms in the U.S.: A cross-national perspective. *The Education Digest, 73*(1), 4.

Parents Involved in Community Schools v. Seattle School District No. 1, 551 U.S. (2007)

Persaud, A., & Freeman, A. L. (2005). *A model for underrepresented minority students' success in engineering: The PreF summer bridge program.* Paper presented at the *American Society for Engineering Education Annual Conference & Exposition*, Portland, OR.

Phillips, B. E. (2002). Top black executives in high-tech and science. *US Black Engineer and Information Technology, 25*(4), 56.

Proposition 209, California State Constitution, Section 31, Article 1 (1996).

Regents of the University of California v. Bakke, 438 U.S. 265 (1978).

Roach, R. (2006). Under construction: Building the engineering pipeline. *Diverse Issues in Higher Education, 23*(2), 24–27.

Rothwell, W. J., & Sredl, H. J. (2000). *The ASTD reference guide to workplace learning and performance: Present and future roles and competencies* (3rd ed., Vol. 1). Amherst, MA: Human Resource Development Press.

Russell, M. L., & Atwater, M. M. (2005). Traveling the road to success: A discourse on persistence throughout the science pipeline with African American students at a predominantly white institution. *Journal of Research in Science Teaching, 42*(6), 691-715.

Sabathia, C. G. (2005, Jun. 2-8). Astronaut Mae C. Jemison: Numbers too low for minorities in science and engineering. *Sentinel,* p. A11.

Schrader, P. G., & Brown, S. W. (2008). Evaluating the first year experience: Students attitudes and behaviors. *Journal of Advanced Academics, 19*(2), 310–343.

Swail, W. S., Cabrera, A. F., & Lee, C. (2004). *Latino youth and the pathway to college*. Washington, DC: Pew Hispanic Center.

Tabachnick, B. G., and Fidell, L. S. (2007). *Using Multivariate Statistics, 5th ed.* Boston: Allyn and Bacon.

Taylor, J. D., & Miller, T. K. (2002). Necessary components for evaluating minority retention programs. *NAPSA Journal, 39*(3), 266.

Technology awareness aims to help transform lives of blacks. (2005). *New York Beacon, 12*(8), 34.

The Education Trust. (2003). *Education watch: The nation*. Washington, DC: Author.

Thomas, R. S. (2000). Black students' performance and preparation for higher education. In S. Gregory (Ed.), *The academic achievement of minority students: Perspectives, practices and prescriptions* (pp. 338–339). Lanham, MD: University Press of America, Inc.

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

Tinto, V. (1982). Limits of theory and practice in student attrition. *Journal of Higher Education*(53), 687–700.

Tinto, V. (1987). *Leaving college: Rethinking the causes and cures of student attrition.* Chicago, IL: University of Chicago Press.

Tinto, V. (1988). Stages of student departure: Reflections on the longitudinal character of student leaving. *Journal of Higher Education*, *59*, 438–455.

Tinto, V. (1997). Classrooms as communities: Exploring the educational character of student persistence. *Journal of Higher Education, 66*(6), 599–623.

Tinto, V. (1999). *Retention and persistence in postsecondary education: A summation of research studies.* Texas Guaranteed Student Loan Corporation.

Tinto, V. (2007). Research and practice of student retention: What next? *Journal of College Student Retention, 8*(1), 1.

Tinto, V., & Love, A. G. (1995). *A longitudinal study of learning communities at Laguardia Community College*: Office of Educational Research and Improvement, Washington, DC.

U.S. Department of Labor, Bureau of Labor Statistics. (2007). *Labor Force Statistics from the Current Population Survey* [Data File]. Available from the Bureau of Labor Statistics Website, http://www.bls.gov/cps/demographics.htm

U.S. News and World Report. (2008) *Best Graduate Schools* [Data File]. Available from the *U.S. News and World Report* website http://grad-schools.usnews.rankingsandreviews.com/grad/eng/search

Waldinger, R., & Lichter, M. I. (2003). *How the other half works*. Berkeley, CA: University of California Press.

Wenglinsky, H. (1998). Finance equalization and within-school equity: The relationship between education spending and the social distribution of achievement. *Educational Evaluation and Policy Analysis, 20*(4), 269–283.

Wilson, J. B., Ellwood, D. T., & Brooks-Gunn, J. (1995). Welfare-to-work through the eyes of children. In P. L. Chase-Lansdale & J. Brooks-Gunn (Eds.), *Escape from poverty: What makes a difference for children?* New York: Cambridge University Press.

Wilson, W. J. (1997). *When work disappears*. New York: Knopf.

Winglinsky, H. (1998). Finance equalization and within-school equity: The relationship between education spending and the social distribution of achievement. *Educational Evaluation and Policy Analysis, 20*(4), 269–283.

Yeung, W. (2008). Black-white achievement gap and family wealth. *Child Development, 79*(2), 303–324.

Zhan, M., & Sherraden, M. (2002). *Effects of mothers' assets on expectations and children's educational achievement in female-headed households.* Working paper. St. Louis, MO: Center for Social Development, Washington University.

APPENDIX A

Data Warehouse Secondary Data

Appendix A.1

Engineering Student Data Available

College of Engineering - Training Lab

College of Engineering's ISIS Data Warehouse

dbo_AIDAA_SP_SU_FA_20XX Table and Field Names

Table Name	Field Name	Field Type	Field Description
dbo_AIDAA_SP_SU_FA_20XX	DEGR_TYPE	text	degree type
	SSN	text	student's social security number
	NAME	text	student's name
	LASTNAME	text	student's last name
	FIRSTNAME	text	student's first name
	MI	text	student's middle initial
	SEX	text	student's gender
	ETHNIC	text	student's ethnicity code
	BIRTH_DATE	text	student's birth date
	HOME_ADDR1	text	student's home address
	HOME_ADDR2	text	student's home address line 2
	HOME_ADDR3	text	student's home address line 3
	HOME_STATE	text	student's home state
	HOME_ZIP	text	student's zip code for home address
	COUNTRY	text	student's home country
	HOME_PHONE	text	student's home phone number
	AGE	text	student's age
	HANICAPCDE	text	student's handicap code
	CITIZENSHIP	text	student's citizenship
	VISA_TYPE	text	VISA type
	VISA_DATE	text	VISA date issued
	COUNTY	text	student's home county

	RESIDENCE	text	student's home residence
	SERV_AREA	text	service area
	EOP_INDC	text	
	EOP_CONSID	text	
	EOP_DY	text	
	VET_DY	text	
	FILLER	text	
	RELIG_PREF	text	religious preference
	BLACKSCHOL	text	
	ATHLETE	text	
	BAND	text	
	CHORAL	text	
	DEBATE	text	
	MAJCHOICE1	text	
	MAJCHOICE2	text	
	CAMCHOICE1	text	
	CAMCHOICE2	text	
	CAMCHOICE3	text	
	SEM_REQSTD	text	
	HOUSE	text	
	APP_DATE	text	
	ALTSUMTERM	text	
	DEGREE	text	
	STATUS	text	student's status
	STAT_DATE	text	
	ADM_SEM	text	admit semester
	ADM_TYPE	text	admission type
	ADM_MAJR	text	admit major
	ADM_CAMPUS	text	admit campus
	HIGHSCHOOL	text	high school
	HS_HONORS	text	high school honors
	HS_GPA	number	high school grade point average
	NS_PGPA	number	
	SCI_PGPA	number	
	HS_CLSRANK	text	high school class rank
	HS_CLSSIZE	text	high school class size

	HS_CLSPSTN	text	
	CS_PSTNWEI	text	
	HSGRADDATE	text	high school graduation date
	RANK_PCNT	number	
	RANT_FIFTH	text	
	CLASS_SIZE	number	
	CLSIZEWGHT	text	
	SAT_VERB	number	SAT verbal score
	SAT_MATH	number	SAT math score
	RELALUM1	text	relative alumni 1
	RELALUM2	text	relative alumni 2
	RELALUM3	text	relative alumni 3
	RELALUM4	text	relative alumni 4
	RESERVED	text	
	COND_OFFER	text	
	ENGR_32	text	
	MAJOR_SCNS	text	
	NONSCICAT	text	
	SCI_CAT	text	
	OFR_PERMIT	text	
	TNTATIVMJR	text	
	COLLEGE	text	
	NCAA_HSGPA	number	
	PROP_48	text	
	ADV_HONORS	text	advanced honors
	FTCAP_DATE	text	FTCAP date
	FTCAP_CAMP	text	FTCAP campus
	FTCAP_TIME	text	FTCAP time
	FTCAP_DATE	text	
	FTCAP_COLL	text	FTCAP college
	FTCAP_PROF	text	
	FTCAP_BALG	number	
	FTCAP_ALG	number	FTCAP Algebra score
	FTCAP_ENGL	numb	FTCAP English score

		er	
	FTCAP_TRIG	number	FTCAP Trigonometry score
	FTCAP_CHEM	number	FTCAP Chemistry score
	FTCAP_CALC	number	FTCAP Calculus score
	PROV_1	text	
	PROV_2	text	
	PROV_4	text	
	IUG	text	
	ACAD_DESCN	text	
	ACAD_DDATE	text	
	GMAT_VERB	number	GMAT Verbal score
	GMAT_QUANT	number	GMAT Quantitative score
	GMAT_TOTAL	number	GMAT Total score
	GRE_VERB	number	GRE Verbal score
	GRE_QUANT	number	GRE Quantitative score
	GRE_ANAL	number	GRE Analytical score
	TOEFL_SEC1	number	
	TOEFL_SEC2	number	
	TOEFL_SEC3	number	
	TOEFL_TOT	number	
	GPA_SOURCE	text	
	QNTY_GPA	number	
	INTNL_FIND	text	
	INTLL_DATE	text	
	MAT_SCORE	number	
	PROFIC_CDE	text	
	PROFIC_SCO	number	
	DEPARTMENT	text	
	UNIV_SCHOL	text	
	PGPA_SCINS	numb	

		er	
	SAT_TOTAL	number	total SAT scores
	ALUM_CLUB	text	
	MIL_BRANCH	text	
	DISCHRGTYP	text	
	MIL_BEG	text	
	COUNTRYCDE	text	country code
	INTNL_SPON	text	international sponsor
	INTNLFAMPL	text	
	INTNLAIDSC	text	international aid source
	BASIC_SKIL	text	
	SATREADSUB	number	
	MRACC	text	
	HS_NAME	text	high school name
	GRAD_HS	text	graduating high school
	GRAD_GED	text	graduating GED
	EARLYADMIT	text	early admit
	HOLD_CODE	text	
	HOLD_SEM	text	
	BLUE_RIB	text	
	APP_MEDIUM	text	
	STUA_ILG	text	
	ETHNIC_DESC	text	ethnic description
	ADM_CAMP	text	admit campus
	RUN	text	
	EMAIL_ADDR	text	email address

Please direct any questions or concerns to the Engineering Training Lab at 3-4666 or email mailto:las@engr.psu.edu
(Updated 10/16/03)

Appendix A.2

Sample of Final Data Set

Student Number	Ethnic	Adm Major	HS GPA	SAT Math	FTCAP Math	CEI (%)	Graduate Outcome
428	4A	ENGR	4.28	791	29	0.88	EGRAD
42	2	ENGR	2.95	470	10	14.35	EGRAD
22	2	ENGR	3.59	500	13	16.07	EGRAD
214	2	ENGR	3.28	730	25	26.03	EGRAD
336	2	ENGR	4	640	21	47.73	EGRAD
92	4A	ENGR	4	580	18	59.77	EGRAD
629	2	ENGR	4.25	691	26	61.03	EGRAD
187	4A	ENGR	2.98	700	24	92.05	EGRAD
107	4A	ENGR	2.26	690	22	0.92	NGRAD
43	4A	ENGR	3.64	521	15	14.41	NGRAD
522	2	ENGR	3.34	730	21	15.90	NGRAD
23	2	ENGR	2.37	580	7	16.06	NGRAD
26	2	ENGR	3.43	410	13	16.09	NGRAD
547	4B	ENGR	3.22	580	15	16.13	NGRAD
385	2	ENGR	3.24	620	16	26.03	NGRAD
341	4B	ENGR	3.35	440	10	48.08	NGRAD
342	2	ENGR	2.75	520	7	48.08	NGRAD
243	2	ENGR	3.14	330	4	59.82	NGRAD
440	4A	ENGR	3.9	500	6	79.62	NGRAD
375	4B	ENGR	3.5	320	6	80.17	NGRAD
446	2	ENGR	3.43	370	3	80.43	NGRAD
283	2	ENGR	2.91	510	10	91.37	NGRAD
506	2	ENGR	3.2	380	10	92.16	NGRAD
312	4B	ENGR	2.83	480	6	93.68	NGRAD
100	4A	ENGR	3.65	620	11	1.04	OGRAD
602	2	ENGR	2.7	470	9	14.40	OGRAD
246	4B	ENGR	3.8	580	23	16.28	OGRAD
338	2	ENGR	2.98	520	4	48.08	OGRAD
215	4A	ENGR	3.35	580	21	79.93	OGRAD
275	1B	ENGR	4.33	570	5	91.37	OGRAD
310	4B	ENGR	3.55	330	6	91.71	OGRAD

APPENDIX B

National Center for Education Statistics (NCES) Secondary Data

Appendix B.1

High School Search Tool

IES NATIONAL CENTER FOR EDUCATION STATISTICS

1990 K Street, NW
Washington, DC 20006, USA
Phone: (202) 502-7300 (map)
NewsFlash|Staff|Contact|Site Index|Help|RSS|Privacy Policy

Search [ ] NCES

Statistical Standards|FedStats.gov

Search for Schools, Colleges, and Libraries

State Pennsylvania **City** Philadelphia Browse For City

Zip **Distance** Miles from Zip

Name Central High School

Sort by Name State City

Institutions
select any of interest (all)

Public Schools ☑
Private Schools ☑
Colleges ☑
Public Libraries ☑

Results: 0 Search

Public Schools

CENTRAL HS
1700 W OLNEY AVE, PHILADELPHIA, PA 19141
215-276-5262 - *PHILADELPHIA COUNTY*
grades: **9 - 12**

Source: CCD Public school data 2005-2006 school year, (**New Schools**)

Public Schools | Private Schools | Colleges | Libraries | Back To Top

Pubs/Products|Surveys/Programs|DataTools|Tables/Figures|FastFacts|School/LibrarySearch|Annuals|What's New|Kids Zone
ED.gov|Institute of Education Sciences|NCER|NCEE|NCSER

Appendix B.2
Sample of High School Information

Search for Public Schools

CCD Common Core of Data

Search Information

Search Results   Modify Search   Data Notes/Grant IDs   Help

School Name:
Central HS

District Name:
Philadelphia City Sd
district information

County:
Philadelphia
schools in county

Mailing Address:
1700 W Olney Ave
Philadelphia, PA 19141-1105

Physical Address:
1700 W Olney Ave
Philadelphia, PA 19141-1105

Phone:
215-276-5262

NCES District ID:	NCES School ID:	State District ID:	State School ID:
4218990	421899003848	126515001	3848

School Characteristics

Grade Span: (grades 9 - 12)

9 10 11 12

Total Students: 2,253
Classroom Teachers (FTE): 104.9
Student/Teacher Ratio: 21.5

Type: Regular school
Old Locale: Large City (1)
New Locale: City: Large (11)
Status: Currently operational

Charter: no **Magnet:** yes **Title I School:** yes **Title I School-Wide Program:** yes

Enrollment Characteristics

Enrollment by Grade:

	9	10	11	12	Ungraded
Students	592	576	562	523	0

Enrollment by Race/Ethnicity:

	Amer Ind/ Alaskan	Asian	Black	Hispanic	White
Students	4	562	744	158	785

Enrollment by Gender:

	Male	Female	Unknown
Students	1,017	1,236	0

Free lunch eligible: 693 **Reduced-price lunch eligible:** 141 **Migrant Students:** 3

Appendix B.3

Sample of Information Provided through the NCES Build-a-Table Tool

National Center for Education Statistics

Common Core of Data (CCD), "Public Elementary/Secondary School Universe Survey" , 1998-99 v.1c, 1999-2000 v.1b, 2000-01 v.1a, 2001-02 v.1a, 2002-03 v.1a, 2006-07 v.1b

Table by School

STATE NAME (SCHOOL)	SCHOOL NAME- MOST RECENT YEAR (SCHOOL)	TOTAL STUDENTS (SCHOOL) [1998-99]	TOTAL STUDENTS (SCHOOL) [1999-00]	TOTAL STUDENTS (SCHOOL) [2000-01]	TOTAL STUDENTS (SCHOOL) [2001-02]	TOTAL STUDENTS (SCHOOL) [2002-03]	FREE AND REDUCED LUNCH (SCHOOL) [1998-99]	FREE AND REDUCED LUNCH (SCHOOL) [1999-00]	FREE AND REDUCED LUNCH (SCHOOL) [2000-01]	FREE AND REDUCED LUNCH (SCHOOL) [2001-02]	FREE AND REDUCED LUNCH (SCHOOL) [2002-03]
Pennsylvania	21ST CENTURY CYBER CS				120	264				0	0
Pennsylvania	A D THOMAS EL SCH	169									
Pennsylvania	A J MCMULLEN SCH	244	238	231	214	232		82	82	78	88
Pennsylvania	A L WILSON EL SCH	160	143	158	163	177		55	76	76	132
Pennsylvania	A W BEATTIE CAREER CENTER										
Pennsylvania	ABINGTON HEIGHTS HS	1,140	1,160	1,202	1,200	1,202		76	69	54	55
Pennsylvania	ABINGTON HEIGHTS MS	1,115	1,130	1,114	1,178	1,207		110	124	112	113
Pennsylvania	ABINGTON JHS	1,836	1,873	1,935	1,892	1,938		163	161	166	159
Pennsylvania	ABINGTON SHS	1,624	1,689	1,791	1,929	1,869		72	111	101	98
Pennsylvania	ABRAHAM LINCOLN EL SCH	307	336	343	356	339		23	18	30	38
Pennsylvania	ACADEMY AT PALUMBO										
Pennsylvania	ACADEMY CS										
Pennsylvania	ACADEMY PARK HS	1,090	1,062	1,077	1,119	1,187		387	383	400	429
Pennsylvania	ACADEMY STREET SCHOOL	371	362	368	341	321		109	101	103	85
Pennsylvania	ACHIEVEMENT HOUSE CS										
Pennsylvania	ACMETONIA PRIMARY SCH	428	420	399	354	330		97	99	108	79
Pennsylvania	ACTS @ WILLIAM PENN SCHOOL										
Pennsylvania	AD PRIMA CS										
Pennsylvania	ADAIRE ALEXANDER SCH	680	661	631	565	525		557	542	468	446
Pennsylvania	ADAMS GR SCH	353									
Pennsylvania	ADAMSTOWN EL SCH	408	418	439	424	428		56	67	56	61
Pennsylvania	ADMIRAL PEARY AVTS										
Pennsylvania	AEP/TRANSITION SCH										

The file contains (**3539**) records based on your search.

*NCES is not responsible for the manner in which this information is presented. This information is provided as an extra service to the user. To download full CCD datasets please go to the CCD home page. http://nces.ed.gov/ccd/

AMY LOUISE FREEMAN

afreeman@engr.psu.edu

PROFESSIONAL PREPARATION

The Pennsylvania State University	Ph.D., Workforce Education	2009
The Pennsylvania State University	M.S., Architectural Engineering	1991
Washington State University	B.S., Construction Management	1982

APPOINTMENTS

The Pennsylvania State University, University Park, PA 2005-present
Assistant Dean of Engineering Diversity
The Pennsylvania State University, University Park, PA 2000-2005
Director, Multicultural Engineering Program
Lock Haven University, Lock Haven, PA 1992-2000
Director, Human and Cultural Diversity
Freeman-Cripe Consulting Services, Lock Haven, PA 1988-1992
Consultant/Owner
The Pennsylvania State University, University Park, PA 1985-1986
Coordinator, Tutoring Service for Engineering Students
Rockwell International, Hanford Operations, Hanford, WA 1982-1985
Construction Engineer

PUBLICATIONS

Freeman, A. L. (2008). *Women in engineering programs in the United States and in Korea: Making best practices even better.* Paper presented at the Women in Engineering ProActive Network (WEPAN) National Conference, St. Louis, MO.

Persaud, A., Freeman, A.L., Salter, D. & Yoder, E., (2006). Work in progress- speaking out on the chilly classroom climate: women engineering students tell all. Conference Proceedings, American Society of Engineering Education- Frontiers in Education Conference.

Freeman, A.L., Persaud, A. (2005). Academic Summer Enhancement (ASE) Program. Conference Proceedings, National Association of Multicultural Engineering Program Advocates

Persaud, A., Freeman, A.L. (2005). A Model for Underrepresented Minority Students' Success in Engineering: The PREF Summer Bridge Program. Conference Proceedings, American Society of Engineering Education

Freeman, A.L., Cripe, J.T (2003). Intercultural Marriages and Child Rearing in E. Farmer, J Rojewski & B. Farmer (Eds.) *Diversity in America: A Vision of the Future*, Kendall/Hunt

LEADERSHIP

President, National Association of Multicultural Engineering Program Advocates 2008-2010
President-Elect, National Association of Multicultural Engineering Program Advocates 2006-2008
Member and University Representative of the following organizations: 2000-present

- National Association of Multicultural Engineering Program Advocates (NAMEPA)
- Women in Engineering ProActive Network (WEPAN)
- Society of Women Engineers (SWE)
- National Society of Black Engineers (NSBE)
- Society of Professional Hispanic Engineers (SHPE)
- National Consortium for Graduate Degrees for Minorities in Engineering and Science, Inc. (GEM)
- American Indian Science and Engineering Society (AISES)
- Society of Advancement of Chicanos and Native Americans in Science (SACNAS)