AC 2010-2401: MONEY, MATH AND ENGINEERING GRADUATION: MORE HIGH SCHOOL FUNDING COULD MEAN MORE UNDERREPRESENTED ENGINEERS

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Money, Math and Engineering Graduation: More High School Funding Could Mean More Underrepresented Engineers

Abstract

What is the effect of insufficient local funding of public high schools on high school math preparation and graduation in engineering? 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 two indicators of standardized math test scores, the high school grade point average (GPA), and poverty level of the public high school community (indicated by the percentage of students qualifying for free or reduced cost lunch).

When college graduation outcomes were evaluated, it was determined that high school poverty was negatively correlated with math preparation. Math preparation was positively correlated with the likelihood of graduation in engineering. A multinomial logistic regression showed that the combined effect of these factors (math test scores, grade point average and community poverty indicator) does explain 76.5% of the variance in college graduation outcome.

Following is a summary of research and findings which include excerpts of the recent doctoral dissertation of Amy Freeman completed in August of 2009.

Introduction

In 2007, African American and Hispanic engineers composed 25.0% of the total workforce in the United States according to the U.S. Department of Labor [31].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[7,9,13,15,21,27,28] . The result has increased enrollments, but also raised legal questions regarding racial preferences. The legal ramifications of race-based access to college admissions, retention services and resources has been reflected in several court cases and anti-affirmative action propositions in the states of California, Washington, and Texas, with others considering this alternative [8, 20, 10].

There is clearly a need for race-neutral solutions that will enhance the education of all students and also bring about the diversity reflected in the population of the US. As additional non-racial barriers are identified and removed, a more equitable number of underrepresented students may attain access to the engineering profession. This study is based on the evaluation of variables associated with economics rather than social and cultural issues that affect graduation outcomes. Because these variables are interconnected, the adjustment of the economic factors could lead to a socially desirable outcome of technological diversity in 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.

Economic Factors

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 study 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 [36]. 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 [25].

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[23].

There were several studies of families receiving welfare and the educational attainment of the children in those families. Ku and Plotnick studied family income data over a 15-year time period[14]. 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 [35]. 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 examined the effects of mothers' assets (home ownership and savings) on their expectations and their children's educational achievement[37]. 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 [6,16].

Tinto 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 [29]. 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 [4].

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 [25, 34].

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. filed a lawsuit against New York State on behalf of New York City students in the late 1990s [2]. 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 8th- 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 [25].

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 [26]. While 63% of those students taking advanced placement calculus courses are White, only 5% are African American and 7% Latino [25]. 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 [23]. 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 [1, 17].

GPA and SAT Scores

High school GPA is still the best predictor of student performance in college [11]. 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 [9].

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 [5, 19].

Methodology

The purpose of this research 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 study involved two research questions:

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

2 For college students who begin in engineering, is there a significant difference in math preparation (high school GPA, SAT score and FTCAP score) for those who graduate in engineering versus those who do not graduate at all? What is the correlation between math preparation and the likelihood of graduation in engineering?

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, other graduates and non-graduates). The goal was to determine how engineering graduation outcomes and math preparation are related, and how poverty (CEI) affects both of these factors.

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 Penn State was counted among these colleges and was ranked at 17 in 2008 by the *U.S News and World Report* [32].

Data Collection

Data were obtained from the official long-term student records of the 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 study included date of admission, race, high school attended, high school GPA, SAT math scores, FTCAP scores indicating calculus preparation, and graduation date. 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. 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, the number of first-year students who attended public schools and were seeking 4-year degrees in engineering totaled 504. This number was a large enough data sample to produce a confidence level of 95% when making inferences to the larger population of approximately 9000 underrepresented students enrolled in the top 25 engineering research institutions in the US.

Dependent Variables

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

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 community economic index (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.

Research Results

Descriptive statistics of the entire group (N=504) are shown in Table 1. 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 2. 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 1

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 2

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

Table 3

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)					_

Statistical Results

The research questions were intended to examine the effects of community economic conditions on academic preparation (research question 1) and the effects of academic influences on graduation outcomes (research question 2). 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.

Correlations of the Community Economic Index and Math Preparation

Research question 1 focused on the correlation between the community economic level (poverty) and academic preparation. Table 3 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). This would suggest that the higher the poverty level of the high school community, the lower the math scores of high school students.

Academic Preparation and Graduation Outcomes

Research question 2 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. 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).

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. The Cox and Snell pseudo R^2 indicates that these combined factors explain 76.5% of the variance in graduation outcomes.

Summary of Findings for Research Questions

Findings for research question 1 regarding the relationship between community poverty and math preparation showed that 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 tax-based funding resources for the high school. The CEI was not found to be significantly related to the GPA.

Findings for research question 2 regarding the relationship between academic and math preparation and graduation outcomes indicated that those students with higher math scores and GPAs were significantly more likely to graduate in engineering (as opposed to changing majors or not graduating at all).

Conclusions, Limitations and Summary

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 1 showing the relationship between poverty, math preparation and engineering graduation.

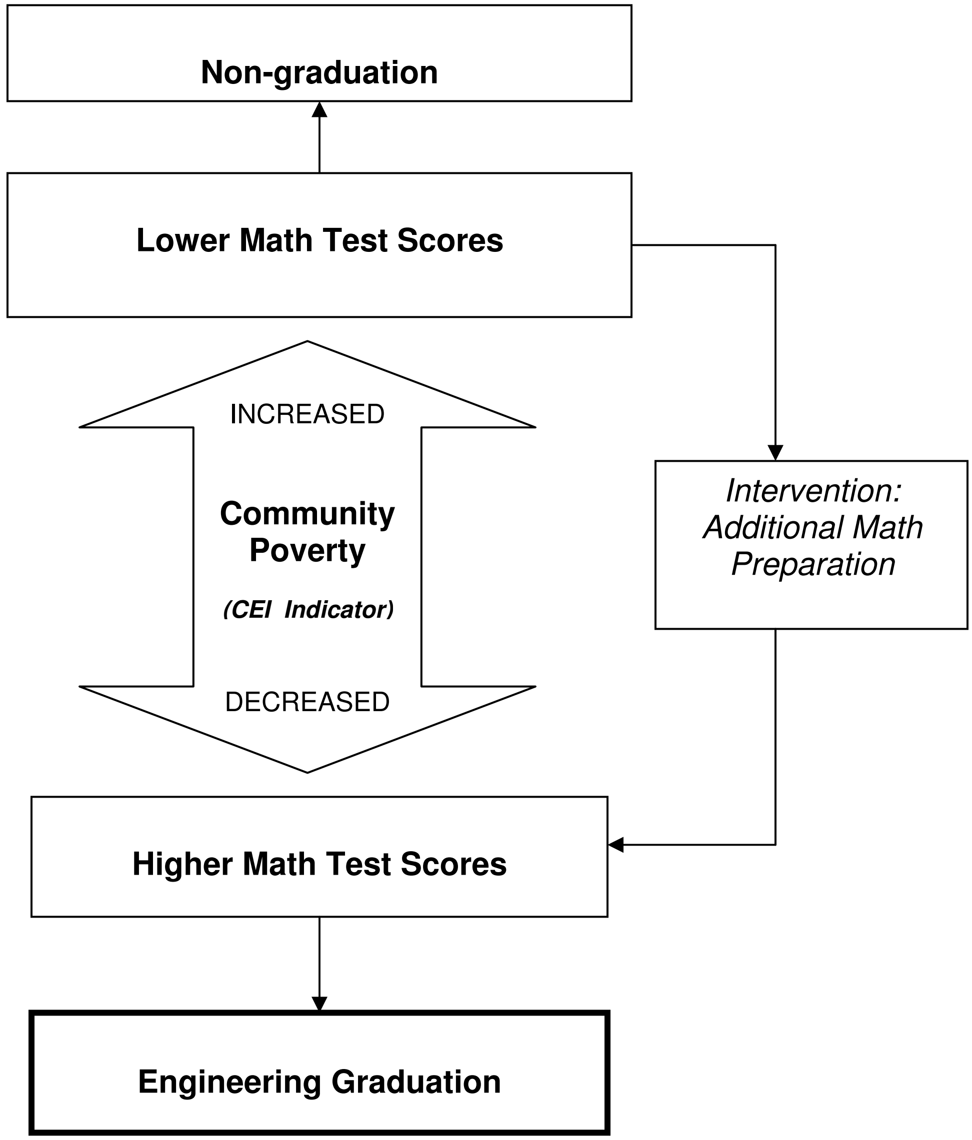

Figure 1. Relationship between poverty, math and engineering graduation.

Poverty is an interesting variable. It is defined in this research by 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. 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 [2, 25]. 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. In the most effective environments, math preparation is defined as a requirement rather than an option [3].

Poverty does not have a significant correlation with GPA (Table 3). 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. Poverty has its strongest connection with engineering graduation through its effect on math preparation.
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Broader Contributions

The contribution of this research 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, this dissertation directly associates community poverty with math preparation of high school students[13, 16, 17, 18, 22, 30]. 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 study 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 this university. 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 the 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.

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 research did not include information regarding the actual occupations that graduating engineers pursue, nor the percentage of engineers who remain in the profession after graduation. This data was compiled using student who attended public schools. These same factors could yield different results if the data set were attendees of private schools.

Although college retention programming was not one of the tangible economic factors in this study, it is important to mention because it has proven critical to the graduation of underrepresented engineers over the past 30 years [7, 9, 13, 15, 17, 21, 27, 28]. Grandy 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 [7]. 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, who placed students scoring lower on standardized math tests in a math-intensive summer bridge program [9]. 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 [17]. Were funding conditions deliberately changed, the yield could be more domestic engineers in the future.

Summary

Upon completion of this study, final data results suggested 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.

The ideal solution for increasing the numbers of engineers in the U.S. would be to provide preparation and 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 could be to evaluate the math education models of technical competitors of the U.S. Perhaps other successful models could be modified to assist us.

If the United States took a different path in the resourcing and implementation of its public education system, one 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)? It is possible that the outcome might not only be more engineers, but more graduates in general and a well informed, more globally competitive citizenry.

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