AC 2011-1394: SOCIOECONOMIC TRENDS IN ENGINEERING: ENROLLMENT, PERSISTENCE, AND ACADEMIC ACHIEVEMENT

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Socioeconomic Trends in Engineering:

Enrollment, Persistence, and Academic Achievement

Abstract

While many studies have examined engineering enrollment, persistence, and academic achievement and a significant amount of literature exists regarding socioeconomic status (SES), the intersection of these is virtually non-existent. This work will begin to bridge the gap between engineering education and SES research by linking two substantial databases. The National Center for Education Statistics (NCES) database includes all public schools in the U.S. and the Multiple Institution Database for Investigation of Engineering Longitudinal Development (MIDFIELD) database currently represents ten institutions and approximately one tenth of all U.S. engineering graduates.

The goal of this study is to identify relationships between socioeconomic status indicators and academic variables, including engineering enrollment, persistence to the 3rd semester, and first year GPA. Academic variables are drawn from the MIDFIELD database and high school codes are used to link National School Lunch Program (NSLP) data from the NCES Common Core of Data (CCD). More specifically, the percentage of students eligible for free lunch at each high school is used as an indicator of socioeconomic status.

It is clear from this study that students from low SES schools are at a disadvantage when it comes to engineering enrollment, academic achievement, and six-year graduation. This trend is not apparent in persistence to the third semester. As new institutions are added in the future, a similar protocol can be used to expand this research further. Issues identified in this study will be used to generate SES models specific to engineering that can begin to inform academic policy, as well as the recruiting and advising of students from all strata of socioeconomic status.

Introduction

Socioeconomic status (SES) is a growing issue in educational equity, diversity, and policy research. Previous work suggests that STEM majors, in addition to having higher measures of academic achievement, also come from higher socioeconomic strata [1]. The goal of this study is to identify relationships between socioeconomic status indicators and engineering enrollment, persistence, and academic achievement. Academic variables will be drawn from the Multiple Institution Database for Investigation of Engineering Longitudinal Development (MIDFIELD) database and high school codes will be used to link data from the National Center for Education Statistics (NCES). Percentage of students eligible for free lunch at each high school will be used as an indicator of socioeconomic status.

Although there have been many persistence studies in engineering education, research on the impacts of SES is limited. First, we must understand what factors determine SES; family income, parent education level, and occupational prestige are common indicators [2]. In *Where the Girls Are: The Facts About Gender Equity in Education*, the American Association for University Women reported that socioeconomic differences outweighed gender and racial differences. The report also indicated that SES differences overlap and could pose as racial differences [3].

"Although higher education research has given only limited consideration to the role of social class, it has long been evident that class plays an important role in education and attainment and should be considered when critically examining educational policy" [4].

Lower SES students are less likely to attend college after high school institutions [5, 6]. In *America's Untapped Resource: Low-Income Students in Higher Education,* Anthony Carneval and Stephen Rose [7] found that 74 percent of students, at the most selective 146 colleges and universities, came from the top socioeconomic quarter of the population, and just 3 percent from the poorest. "In other words, one was twenty-five times as likely to run into a rich kid as a poor kid on the nation's selective campuses" [2]. Even more recently, *The Chronicle of Higher Education,* found that selective colleges have wealthier students, which raises concerns about the extent to which colleges offer a path for upward mobility to socioeconomically disadvantaged students [8].

The work of Fenske et al. [1] is one work that does integrate financial aid, gender, race/ethnicity, and academic major and implies STEM majors often come from higher SES strata and have higher measures of academic achievement. It is somewhat surprising that the authors suggest that students with merit-based aid may persist less than their more financially needy peers. It is evident that research suggests a correlation between SES and access to postsecondary education as well as persistence in engineering. Still, further research is necessary to be certain about SES barriers facing undergraduate engineering students.

Previous research shows that there is a relationship between school population socioeconomic status and individual academic achievement. School population poverty status is based on the National School Lunch Program in which "any child at a participating school may purchase a meal through the National School Lunch Program. Children from families with incomes at or below 130 percent of the poverty level are eligible for free meals. Those with incomes between 130 percent and 185 percent of the poverty level are eligible for reduced-price meals, for which students can be charged no more than 40 cents. For the period July 1, 2010, through June 30, 2011, 130 percent of the poverty level is $28,665 for a family of four; 185 percent is $40,793" [13]. Using free and reduced lunch enrollment as an indicator of both school and family poverty status, Caldas and Bankston show that there is a negative correlation between individual academic achievement and both individual and school poverty statuses. School poverty status was only slightly less correlated than individual poverty status[14]. Based on this earlier work, a new SES indicator, Peer SES has been defined for use in this study. Peer SES (pSES) is a measure of the percentage of students NOT eligible for the free lunch program, thus a high pSES score indicates that a student attended a high socioeconomic status secondary school. Although school poverty status does not give a direct indication of an individual student's household socioeconomic status, it does indicate the resources that the student is exposed to in his or her academic environment.

The study aims to answer several questions regarding the relationship between school poverty status and individual academic achievement, persistence, and enrollment in engineering:

- Are students with lower Peer SES matriculating into engineering at the same rate as their higher SES peers?
- Are students with lower Peer SES more or less likely than their higher SES peers to persist in engineering to the third semester?

- In our database, is Peer SES related to individual academic achievement?

We are expecting to see a negative correlation between percentage of free lunch and engineering enrollment, academic achievement, and persistence, meaning students from lower SES schools will be less likely to choose engineering as a college major, have lower GPA's, and be less likely to continue in engineering past the 3rd semester.

Methodology

The study uses a correlational design method [15] with a focus at the end of students' first year in college. Academic variables (engineering enrollment, persistence to the 3rd semester, and first year GPA) are drawn from the MIDFIELD database and high school codes are used to link data from the NCES. Regression techniques are used to determine the predictive power of our SES indicator, Peer SES.

High School Data

The NCES CCD includes 29,171 public schools that taught 12th grade between the 1987 and 2004 school years[16]. Of these, 87% had valid free lunch and enrollment records for at least one year in the time period.

The total number of students eligible for free lunch in all years divided by the total enrollment in all years represents an average percentage of students eligible for free lunch at each school. This variable is then transformed by subtracting from 100% to yield the percentage of students not participating in free lunch and referred to as Peer SES, or pSES. Therefore, high values of pSES represent high SES schools. It is important to note that pSES is not an indication of a student's household SES, but rather an indicator of their school environment.

Institution Data

The MIDFIELD database includes 6-year graduation records for 367,289 students at 10 institutions. One institution was removed from the study because they did not report high school codes. A second institution did not report complete high school data before 1994. Individual students whose high school code was missing or invalid were also removed, leaving 290,938 student records. Using a crosswalk compiled by Matthew Chingos, a postdoctoral researcher at Harvard and co-author of *Crossing the Finish Line* [17], 87% of the students with College Board (CEEB) high school codes were able to be matched with NCES high school codes that had a pSES value.

First-time students in MIDFIELD had a mean pSES of 86.63, almost one half standard deviation above average, indicating that students at low pSES high schools are less likely to attend college. The median pSES value for this group was 88.99 and the mode was 100 (no students eligible for free lunch). The minimum value of 2.57 represents a student who went to a school where over 97% students are eligible for free lunch. Nearly the full gamut of pSES is represented in the MIDFIELD database, although not uniformly so. The 55,132 students who matriculated into an engineering field (and had a pSES value) had an even higher average pSES of 87.29 and a minimum value of 11.61.

Data Analysis

Logistic regressions are used to identify trends in the dichotomous outcome variables engineering enrollment (whether or not a student matriculated into engineering) and persistence (whether or not a student continued in engineering to the third semester). Linear regression is used for first year GPA, which is a continuous outcome variable on a scale of 0 to 4 (with 4 being straights A's). For simplicity of interpretation, peer SES was rescaled to a range of 0 (low peer SES: all students eligible for free lunch) to 1 (high peer SES: no students eligible free lunch).

Results and Discussion

Engineering Enrollment

Engineering professions have been far less successful than other professions at attracting female students. While the overall percentage of Bachelor degrees conferred to women in the 2005-2006 academic year was 57%, in engineering only 19% of the graduates were women[18]. Previous work with the MIDFIELD database also shows that gender is a significant factor in engineering enrollment[19]; therefore, it is included in the engineering enrollment model in addition to the variable of interest, pSES. Using stepwise selection, pSES ($p < 0.0001$), gender ($p < 0.0001$) , and their interaction ($p < 0.0034$) were found to be significant ($\alpha=0.05$) predictors of engineering enrollment. The logistic model shows that females and males with high peer SES are 1.446 and 1.996, respectively, times more likely than their low peer SES counterparts to matriculate into engineering. As peer SES increases, the probability gap between males and females increases (Figure 1). Without accounting for any other variables, peer SES is a stronger indicator of engineering enrollment for males than it is for females.

Table 1: Logistic regression of pSES and gender on engineering enrollment (adjusted R-square = 0.1041)

Parameter	Degrees of Freedom	Estimate	Wald Chi-Square	p-value	Odds ratio
Intercept	1	-1.3629	668.4446	< 0.0001	
Gender	1	-1.0849	128.0083	< 0.0001	0.338
pSES	1	0.6912	132.7990	< 0.0001	1.996
Interaction (pSES*Gender)	1	-0.3222	8.6051	0.0034	0.725

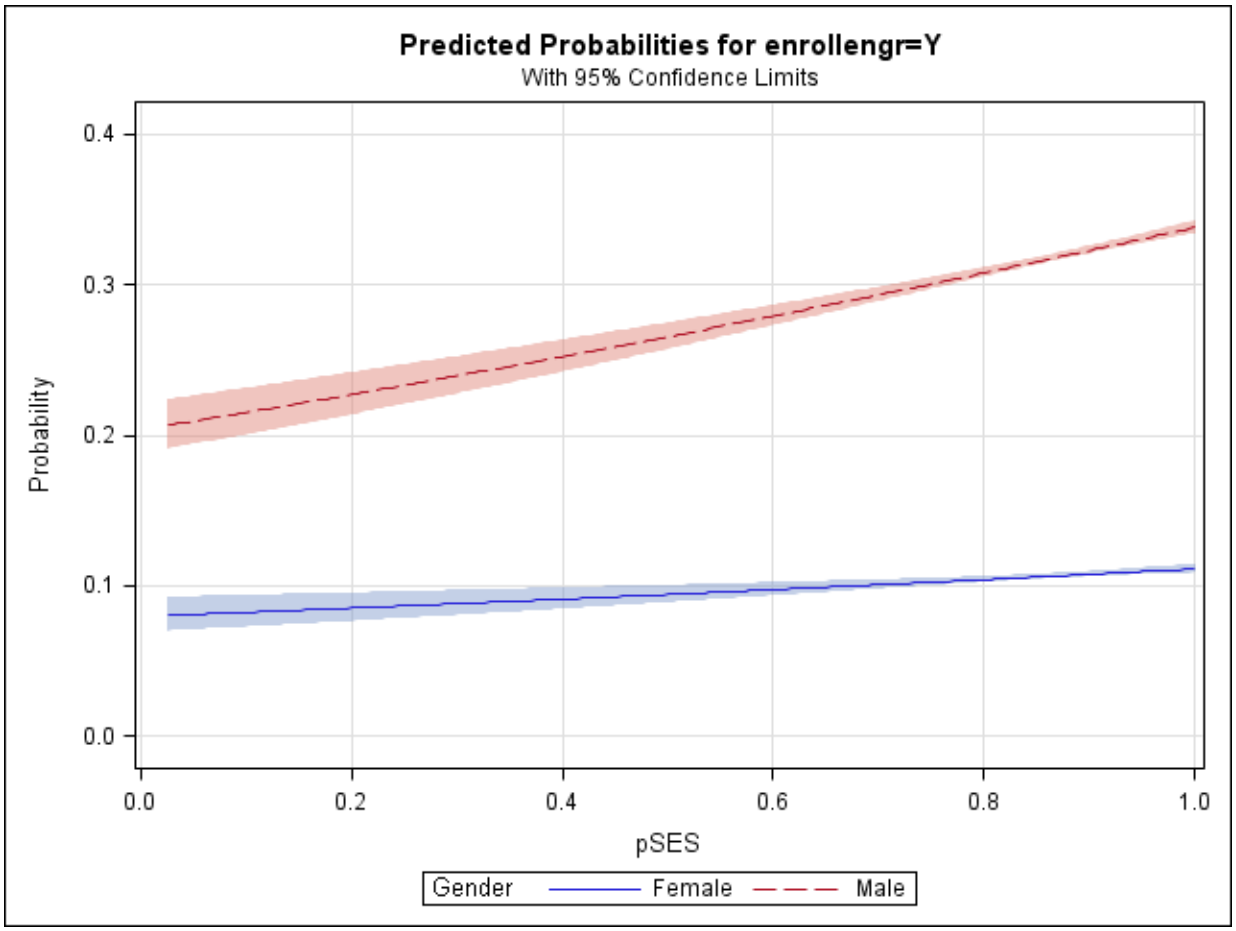

Figure 1. Predicted probabilities of enrolling in engineering with 95% confidence limits

Persistence

Gender was not included in the persistence model because previous work has shown that in the MIDFIELD dataset, women are just as likely to persist in engineering as men, although there were notable differences in pathways chosen by the remaining men and women [20]. Over 87% of students who matriculate into engineering are still enrolled in an engineering major in their third semester.

Table 2: Logistic regression of pSES on persistence in engineering to semester 3

Parameter	Degrees of Freedom	Estimate	Wald Chi-Square	p-value	Odds ratio
Intercept	1	2.0602	286.6650	< 0.0001	
pSES	1	0.0602	0.1894	<0.6634	1.062

As shown in Table 2, pSES is not a significant predictor of persistence to the third semester. It is possible that this is because so few students have left engineering at this stage. To further explore this phenomenon, a model was created for predicting six-year graduation in engineering. Results were quite different (Table 3). The odds of a high pSES student graduating in

engineering in six years are approximately five times better than the odds for a low pSES student.

Table 3: Logistic Regression of pSES on Six Year Graduation in Engineering (adjusted R-square = 0.0094)

Parameter	Degrees of Freedom	Estimate	Wald Chi-Square	p-value	Odds ratio
Intercept	1	-1.5473	434.8354	< 0.0001	
pSES	1	1.6387	378.4295	<0.0001	5.148

Figure 2 shows that a student with high pSES has a probability of 0.522 of graduating in engineering in six years while a low pSES student has only a probability of 0.175.

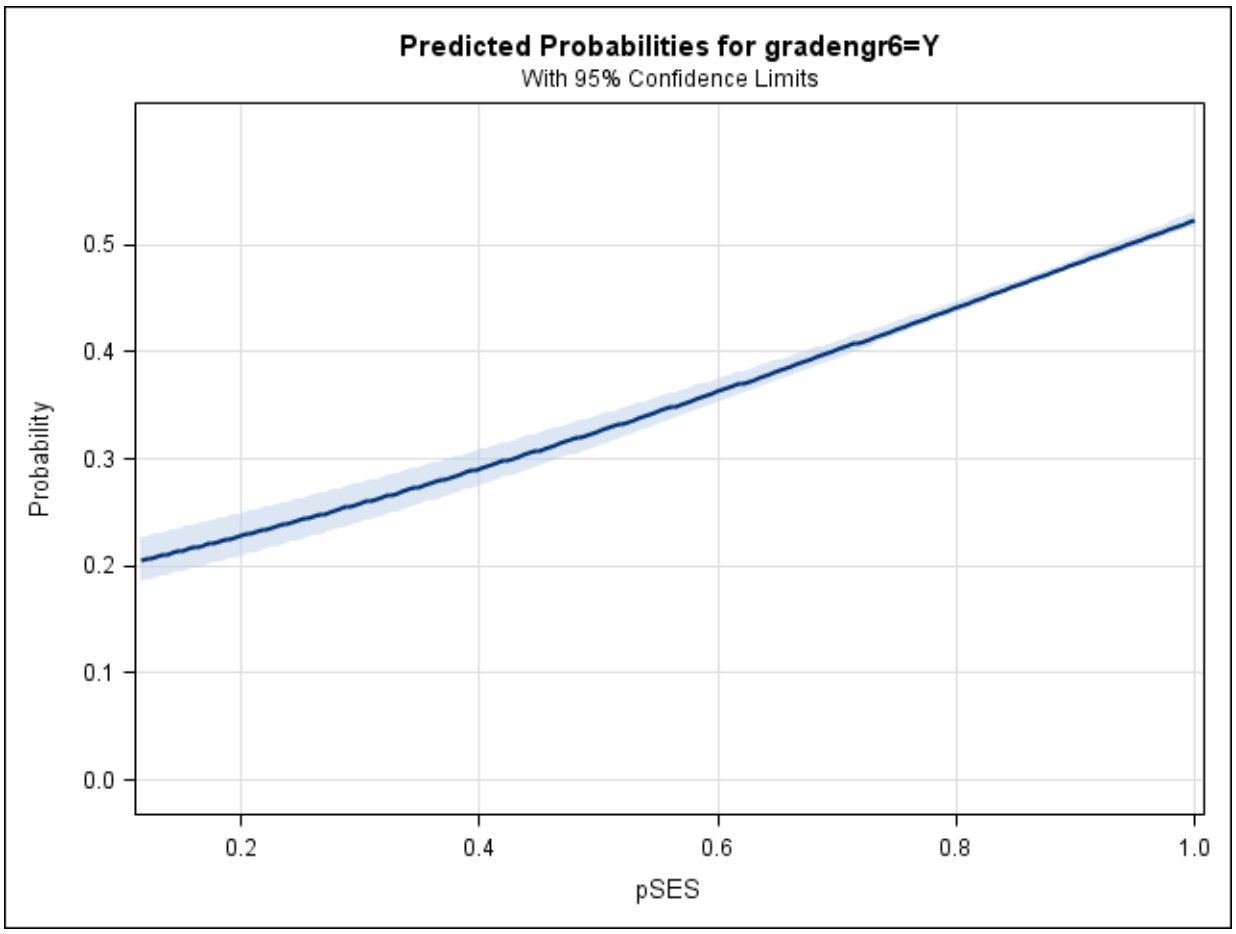

Figure 2: Predicted probabilities for six-year graduation in engineering with 95% confidence limits

Academic Achievement

Academic achievement was examined using first-year GPA as an indicator. This linear regression indicates that the average GPA for a student with pSES = 0 is 2.09, or a C average. Having pSES =1 increases that average by 0.7. This confirms prior research that either low SES

schools are not adequately preparing students for college engineering and/or first year courses do not seem to be helping them catch up. Low peer SES students begin their sophomore year at a significant disadvantage. Future studies will examine whether this effect tapers off or compounds as students progress.

Table 4: Regression of pSES on first year GPA (adjusted R-square = 0.0085)

Parameter	Degrees of Freedom	Estimate	Standard Error	t Value	p-value
Intercept	1	2.08829	0.02880	72.52	< 0.0001
pSES	1	0.70086	0.03270	21.43	<0.0001

Conclusions and Future Work

It is clear from this study that student from low SES schools are at a disadvantage when it comes to engineering enrollment, academic achievement, and six-year graduation. Nevertheless, the impact of attending a low-SES school is not apparent in persistence to the third semester. This has significant implications for advisors and policy makers, in that these students might not exhibit any warning signs before they leave engineering without a degree. As unfortunate as it would be if those students were unable to persist to the third semester of engineering, it would be even more disappointing if they were encouraged to hold on to the promise of an engineering degree for additional years, only to reach a later barrier before completion of the degree.

Future work will focus on studying institutional differences, including academic variables, determining at what point the pSES starts to significantly affect persistence , and looking for trends in what happens to students after they leave engineering, i.e., do they change majors or leave the institution? To what majors do they switch? How is their destination related to their peer SES? The development of this peer SES metric and its connection to the MIDFIELD database open a wide range of new possibilities for exploration. Developing a better understanding of the relationship between the choices students make and their background is the first step toward increasing socioeconomic diversity in engineering, thus providing opportunities for the upward mobility of disadvantaged students and informing decisions regarding academic recruiting, advising, and policy.

References

1. Fenske, R.H., J.D. Porter, and C.P. DuBrock, *Tracking Financial Aid and Persistence of Women, Minority, and Needy Students in Science, Engineering, and Mathematics.* Research in Higher Education, 2000. **41**(1): p. 67-94.
2. Kahlenberg, R.D., ed. *Rewarding Strivers: Helping Low-Income Students Succeed in College*. 2010, The Century Foundation Press: New York.
3. Corbett, C., C. Hill, and A. St. Rose, *Where the Girls Are: The Facts About Gender Equity in Education*. 2008, American Association for University Women Educational Foundation: Washington, D.C.
4. Paulsen, M.B. and E.P.S. John, *Social Class and College Costs: Examining the Financial Nexus between College Choice and Persistence.* The Journal of Higher Education, 2002. **73**(2): p. 189-236.

5. Adelman, C., *Principal indicators for student academic histories in postsecondary education, 1972-2000*. 2004, Washington, D.C.: U.S. Department of Education Institute of Education Sciences.
6. Thomas, S.L. and L.W. Perna, *The opportunity agenda: A reexamination of postsecondary reward and opportunity*, in *Higher education: Handbook of theory and research*, J.C. Smart, Editor. 2005, Kluwer Academic Publishers: The Netherlands. p. p. 43-84.
7. Carnevale, A.P. and S.J. Rose, *Socioeconomic Status, Race/Ethnicity and Selective College Admissions*, in *America's Untapped Resource: Low-Income Students in Higher Education*, R.D. Kahlenberg, Editor. 2004, Century Foundation Press: New York. p. 106, Table 3.1.
8. (2010) *Socioeconomic Diversity: Advantage for Wealthy Students*. The Chronicle of Higher Education.
9. Fischer, K. (2008) *Top Colleges Admit Fewer Low-Income Students: Pell Grant Data Show a Drop since 2004*. Chronicle of Higher Education.
10. Alon, S., *The influence of financial aid in leveling group differences in graduating from elite institutions.* Economics of Education Review, 2007. **26**: p. 296-311.
11. DesJardins, S.L., D. Kim, and C.S. Rzonca, *A nested analysis of factors affecting bachelor's degree completion.* Journal of College Student Retention, 2003. **4**(4): p. 407-435.
12. Kim, D., *The effect of loans on students' degree attainment: Differences by student and institutional characteristics.* Harvard Educational Review, 2007. **77**(1): p. 64-100.
13. *National School Lunch Program Fact Sheet*. 2010; Available from: http://www.fns.usda.gov/cnd/lunch/AboutLunch/NSLPFactSheet.pdf.
14. Caldas, S.J. and C. Bankston, *Effect of School Population Socioeconomic Status on Individual Academic Achievement.* The Journal of Educational Research, 1997. **90**(5): p. 269-277.
15. Creswell, J.W., *Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research*. 3rd ed. 2008, Upper Saddle River, New Jersey: Pearson Education, Inc.
16. National Center for Education Statistics. *CCD - Build a Table*. 2010; Available from: http://nces.ed.gov/ccd/bat/.
17. Bowen, W., M. Chingos, and M. McPherson, *Crossing the finish line: Completing college at America's public universities*. 2009: Princeton Univ Pr.
18. United States Dept. of Education, *Table No. 265: Bachelor's, master's, and doctor's degrees conferred by degree granting institutions, by sex of student and field of study: 2005-06*. 2007, National Center for Education Statistics, 2005-06 Integrated Postsecondary Education Data System (IPEDS).
19. Ohland, M.W., et al., *Persistence, Engagement, and Migration in Engineering Programs.* Journal of Engineering Education, 2008. **97**(3): p. 259-278.
20. Lord, S.M., et al., *Who's Persisting in Engineering? A Comparative Analysis of Female and Male Asian, Black, Hispanic, Native American, and White Students.* 2009. **15**(2): p. 167-190.