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WHO SUCCEEDS IN ENGINEERING AND OTHER STEM STUDIES?

AN ANALYSIS OF BINGHAMTON UNIVERSITY UNDERGRADUATE STUDENTS

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ABSTRACT

Using data from ten cohorts of entering students, both freshman and transfer students, the characteristics of Engineering, of other STEM, and of Non-STEM students are examined for attributes associated with academic success. We use Logit and GMM, both as fixed effects models (for high school), to analyze the various indicator variables' role in attaining success. We find that the preparation and ability, as evidenced by High School GPA, appropriate Advanced Placement course work, mathematical ability, gender, ethnicity, and the student's college experience are all statistically significant indicators of college success. The Engineers have statistically significant differing response elasticities than the Non-Engineers for many of these variables. Other tests of this data are reported as are some descriptive statistics that enhance our understanding of STEM majors. A successful Engineering STEM major at Binghamton has good math preparation, enters engineering as a freshman, and is of Asian ethnicity. Women are few in numbers as Engineers. All other STEM fields see less emphasis on math preparation, but more on the presence of AP course work, and are not enrolled in as rigorous a lock-step program necessitating freshman entry as are Engineers. Women also seem to have the same presence in these other STEM fields as in the whole university.

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I. INTRODUCTION

This paper deals with the characteristics of STEM students at Binghamton University (State University of New York at Binghamton) and it explores the differences between STEM students and Non-STEM students in an attempt to shed light on the question of STEM student's academic success, or lack thereof.

This question of academic success is important for American society and the apparent paucity of STEM students is of national concern. .As an example considers engineers. The number of undergraduate students earning a degree in engineering and engineering technologies has fallen about 16 percent over a twenty year period (1985-86 to 2005-06). The first fifteen of these years saw a decline of 25%. But, the last five saw the number of degrees conferred in engineering and engineering technologies increased 12%, though the numbers did not reach the level of 1985-86[3]. The decline was uneven when specific fields are considered. For example, Chemical and Civil engineering had positive growth from 1985-86 to 1995-96. But From 1996-97 to 2001-02 all the engineering fields declined.

If one looks at the history of people who are successful in the arts such as music or dance, or one considers people who are successful in highly technical fields such as astrophysics, we find these individuals often had an interest in their area since early childhood or at the least, since middle school. Successful swimmers have been swimming since they were three years old; and if you try to join a track team in high school, the coaches want to know how well you did in middle school track. So it should

[3] NCES (2007). Digest of Education Statistics. Table 304.

be no surprise that the successful students in STEM courses probably had an interest in STEM fields for many years before college.

Much of the research and data analysis focus has been on STEM precursors in K-12 schools. Various international surveys on high school students' science and math performance have found that United States is not doing as well in science and math education as hoped. See The Programme for International Student Assessment (PISA)[4] and The Trends in International Mathematics and Science Study (TIMSS). The 2007 TIMSS report ranked US 8th on fourth grader and 11th on eighth grader science scales and 10th on math score (up from 12th in 2003)[5].

However, little attention has been focused on the problem in higher education and the observed high dropout rates from science and math majors. Female and/or non-white students opt out of STEM majors at disproportionate rates. Apart from the K-12 system, US Universities have not kept pace with rest of the world in the production of STEM graduates. Even though young student's interest in STEM careers may start much before they enter college/university, it's the postsecondary education that creates the career path and prepares a student to work in a STEM occupation. Hence, it is important to analyze the university/college experience with of STEM courses and the reasons for the high attrition rates from STEM majors.

The National Academies report *Rising above the Gathering Storm* which states that science and technology is important to US's economic growth, warns that a faltering US science and mathematics higher educational system may have serious implications for the nation's competitiveness in coming years in aspects of introducing new technologies, creating high paying jobs and improvements in lifestyle. [6]

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[4] PISA a worldwide evaluation of 15-year-old school children's scholastic performance performed first in 2000 and repeated every three years. It is coordinated by the Organization for Economic Co-operation and Development (OECD), with a view to improving educational policies and outcomes. See http://en.wikipedia.org/wiki/Programme_for_International_Student_Assessment

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[6] **Stacy Teicher Khadaroo(2007). "World's schools teach U.S. a lesson". Christian Science Monitor.**

A more recent report,"*Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education,"* by the US Department of Education[7] tried to dig deeper into the STEM student's characteristics. This is discussed in the literature section in depth, but here we note that this report too sounds an alarm.

Our paper examines the validity of some of the hypotheses that have been offered to explain the gap between intended and completed STEM field majors using data from the Binghamton University. We must caution the reader here that we have not found a clear answer to these questions, but you should read on to see what is important including the differential of the correlates of academic success among various STEM fields.

I n the sections that follow, we first consider some definitional issues, and then offer a review of relevant literature, and this is followed by a description of Binghamton data. Next we discuss the hypothesis we try to test and postulate several models for subsequent econometric analysis. This is followed by a discussion and conclusion.

II DEFINITIONAL ISSUES: STEM STUDENTS AND ACADEMIC SUCCESS

As a starting point for the reader, it is useful to define what a STEM field is and then what we use as measures of academic success.

A definition of what is a STEM degree is given by the National Center for Education Statistics which has developed a list of designated degree programs that are science, technology, engineering, or math degrees[8]. However, the National Science Foundation (NSF) defines STEM fields more broadly and includes not only the common categories of mathematics, natural sciences, engineering, and computer and information sciences, but also such social/behavioral sciences as psychology, economics, sociology, and political science (Green 2007). This classification issue is discussed in Students *Who Study Science, Technology, Engineering, and Mathematics (STEM) in*

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[7] http://nces.ed.gov/pubs2009/2009161.pdf
[8] See http://www.ice.gov/doclib/sevis/pdf/nces_cip_codes_rule.pdf for a list

Postsecondary Education[9]. We applied the first definition, eliminating the social sciences from our study. Using the Binghamton list of majors, we found 18 engineering majors and 34 other non-engineering STEM fields in which degrees were offered. The list is given in the appendix.

The definition of success is a more philosophical one. We could postulate grades, graduation rates, persistence, completion time or time to degree, or some other metric. Measures such as GPA and time to degree are also easy to measure but persistence is not. A student may ‘persist’ in their quest for education and a degree at many campuses and schools over the course of many years. This may mitigate the perceived high dropout rates. And the scientific community has need for substantial numbers of support personnel as do engineers. These may be provided from the ranks of those who formally drop out of STEM studies but are better trained individuals for their academic experience. We are not able to follow such a student or dropout with our data and this is thus not addressed herein.

Using Grade Point Average as a measure of success is common in higher educational studies, and the reader should note that we frequently use this metric in this paper, but this too has its limitations. For example, Bretz, using Meta analysis, found that success in field is weakly related to GPA for some (e.g. teaching) but not related to success in most fields[10]. So if we measure GPA, we may not be measuring success however you define it.

Graduation rates are another measure of success but also have problems. There are reasons to use graduation as a measure of success including its popularity; graduation rates are used in the ranking of schools[11], in setting and evaluating admissions

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[9] http://nces.ed.gov/pubs2009/2009161.pdf

[10] Robert D. Bretz Jr, 1989**,** College Grade Point Average as a Predictor of Adult Success: A Meta-Analytic Review and Some Additional Evidence, Public Personnel Management, Vol. 18, 1989

[11] College rankers often include graduation rates (e.g. *US News & World Report*) along with generic institutional data to develop their rankings[11].

criteria[12], and in measuring accountability and efficiency. A wide range of possible explanations for individual student or institutional graduation rate variation have been studied and it has been found that student experiential variables, student ability, other pre-college variables as well as many institutional variables are important. In other words, the success of a student as measured by graduation is partially controlled by institutional characteristics, particularly funding. A good introduction to modern research on this issue together with a good bibliography is given in Scott, Bailey and Kienzl (2008). Also see DesJardins, Kim and Rzonca (2002-2003) and Braxton and Hirschy, (In press), Berger and Lyons, (in press), and Porter (2003-2004). Many of the issues are identified in Habley and McClanahan (2005). Adelman (1999) is also useful.

A further criticism of graduation or grades as a measure of a successful outcome is that they do not reflect the quality of the education of the student. The time students spend in exploring different majors and taking elective courses may better prepare them to be life-long learners and better citizens. From this perspective, time-to-degree and graduation rates are not the only measures of the educational output, but the intelligence, the existence of a breadth of knowledge, understanding, and personal satisfaction of the citizenry as well as their contribution to the commonweal are.

Further, both grades and graduation often do not consider variations in the length of a degree program. The idea of a traditional four-year degree program is not universal and this is relevant to STEM studies, many engineering and architectural programs and some other programs such as three-two programs, where the student spends time in industry or some other field of study such as business, often require five years of study.

Also, certification in some sub-field, employment, earnings subsequent to graduation, marriage, citizenship, and literacy are some further possible measures of success.

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[12] The higher education community recognizes that admission standards, the academic strength of the enrolled students, and, most importantly, the resources institutions devote to instruction, to remediation, and to retention are important. So graduation rates reflect many institutional variables that may mask the attributes of students. The use of graduation rates in setting admission standards is well-discussed in Archibald and Feldman, 2008.

There is some evidence that certification or its equivalent is useful in the STEM field of computers or information technology[13].

Much of the literature of these metrics is descriptive and/or discusses the relationship among various student and institutional characteristics and the outcome. Baseline studies by Tinto (1975 and 1993), Bean (1980), Pascarella and Terenzini (1991) and Astin (1992) omit the role of resources, other than student financial assistance. Kuh's (2002) research into student engagement finds most, if not all, of the educational engagement factors studied have significant financial implications for the institution. And work by Blose ET. Al. found that institutional expenditures adjusted for types of majors etc. to be most important in helping students achieve timely graduation and this is consistent with the Students Who Study Science study.

III LITERATURE

Very few studies analyzing university/college education of STEM use longitudinal data, but two recent, notable studies are by Xie and Shauman (*Women in Science*, 2003)[14] and also Ohland et.al. (*Persistence, Engagement, and Migration in Engineering Programs,* July 2008)[15]. *Women in Science* addressed the issue of the low participation of women in science fields by looking at the entire science career trajectory, starting from high school and ending in doctoral degrees doing so by analyzing seventeen large datasets.

The main contribution of the book is the introduction of the "life course" perspective to study science careers, a model unlike the 'pipeline model" which is commonly used to explain women's choices about science. The "pipeline model "assumes that a structured or particular educational path leads to a career in science, while the "life course" perspective views the science career trajectory as life long process. It takes into

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[13] See *Students Who Study Science, Technology,Engineering, and Mathematics (STEM) in Postsecondary Education*

[15] Ohland,M.W., Sheppard, S.D., Lichtenstein, G., Eris, O.,Chachra, D. and Layton, R.A. (2008). "Persistence, Engagement, and Migration in Engineering Programs". *Journal of Engineering Education*. Vol.97 (3). pp.259-278.

account the dynamic educational and socioeconomic events that take place in an individual's life which shapes his or her career choices.

Xie and Shauman studied the performance of high school students in science and mathematics by analyzing the mean gender difference in math and science achievement scores on tests administered by six nationally representative longitudinal surveys[16] and found the mea differences to be small in magnitude (no significant difference in math and science achievement of females compared to males). In the case of undergraduate education in science and engineering the importance of persistence and migration into and out of STEM fields and the combinations of these forces determining the number of STEM graduates was highlighted. Continuing in STEM major or early entry (within first two years of baccalaureate education) into STEM major from a non-STEM major was found to be the most important factor contributing to achieving baccalaureate degree in science. Late entry into a STEM major or re-entering into a STEM major (students who switched from STEM major to Non-STEM major and back to a Non-STEM) does not necessarily lead to a science degree.

The question of persistence, engagement and migration (both in and out) in baccalaureate engineering programs is addressed by Ohland et.al. (July 2008). The paper proposed that engagement is precursor to persistence. The focus of the paper was only on engineering programs and comparisons were made against students in other academic programs (which included STM programs) in terms of persistence in the major they matriculated in and staying on in the same university where they enrolled for the first time.

The difference in the rates of persistence between the Engineering major and the other academic majors was found to be small except that in-migration of students into Engineering major from other majors is very low compared to other majors who attract students away from Engineering majors. Hence students who graduate in Engineering are the ones who moved into it quite early on in their academic career, a result which was also found by Xie and Shauman.

[16] (NLS-72, HSBSO, HSBSR, NELS-88, LSAY1, and LSAY2)

The rates of persistence of men and women in Engineering major were found to be similar and no significant differences existed among racial/ethnic groups even though the gender distribution of Engineering majors is skewed more towards males. Ohland et.al. looked at engagement in engineering major by analyzing the eight engagement and six outcome scales from National Survey of Student Engagement (NSSE 2006)[17]data and looking at Persistence in Engineering (PIE)[18] data from Academic Pathways Study (APS). Engineering majors were found to be no different from other major groups in terms of involvement in working on campus and time spent on various leisure activities. Substantial positive differences existed in terms of internships, experience, and involvement in research projects with faculty; and negative differences exist for those taking foreign language classes and participating in study abroad programs. Using PIE survey data from APS Longitudinal Cohort, the relationship between engagement and persistence was investigated. For students who persisted in engineering majors, their academic disengagement from both liberal arts courses and other fields of engineering increases as they progress in their undergraduate education, but their level of disengagement from liberal arts courses is much higher relative to courses in other engineering.

A more recent report, *Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education, by* the US Department of Education,[19] tried to dig deeper into the STEM student's characteristics. It provide(s) "a profile of undergraduates who pursue and complete STEM degrees. It uses several data sets to address three questions: (1) who enters STEM fields? (2) What are their educational outcomes (i.e., persistence and degree completion) several years after beginning postsecondary education? (3) Who persisted in and completed a STEM degree after entrance into a STEM field of study[20]?

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19 http://nces.ed.gov/pubs2009/2009161.pdf

20 See *Students Who Study Science, Technology, Engineering, and Mathematics (STEM) in Postsecondary Education, page 1 ff.*

Factors influencing graduation and persistence of engineering students have also been investigated by Zhang, Anderson, Ohland, Carter and Thorndyke (2002); Fleming, Engerman, Griffin (2005); Eris, Chachra, Chen, Rosca, Ludlow, Sheppard and Donaldson (2007); Cain, Fleming, Williams and Engerman (2007); Alting and Walser (2007); and Kilgore, Atman, Yasuhara, Barker and Morozov (2007).

A tabular synopsis of the literature is given in the Appendix. It lists, for each article or book the Author, the Journal/WP/Publication, the Main Research Question, the Sample/Database, Variables, Methodology, and the Main Result.

Papers researching factors determining persistence and graduation in engineering degrees point out that having an interest in engineering, science or mathematics is crucial to pursue a degree in engineering. Along with interest in STEM subjects, the kind of college experience an engineering student faces in the first two years of college was found to be very important as attrition rates among engineering students is high during the first two years. Therefore the first two years in college play a significant role in helping a student focus more on engineering major or move away from it to pursue something else.

In summary, the vast literature sheds much light on the nuances and identifies interesting and useful details, but poses no easy solution that is universal and none with confidence.

IV BINGHAMTON DATA

The data for Binghamton University was provided by the *Office of Institutional Research* at Binghamton and was garnered from various administrative and student records. The Data consists of 926,759 observations at the Student-course Level for 176 variables, and covers 1997 Fall Term through 2007 Spring Term. There are over 44,000 individuals or subjects. The Data Appendix contains Summary data for Binghamton along with further details.

The summary characteristics of Binghamton students who were awarded a degree are given in Table 1. Data is provided for All Binghamton Students, Engineers, other STEM students, Chemistry students (a STEM field), Economics and English. These last three are for illustrative purposes with Economics being considered a hard grading non-STEM Department and English an easy grading non-STEM Department[21].

Note that STEM graduates are very much in the minority; only 1267 (first numeric column) were non-engineering STEM grads and that is 5.22 percent of the total undergraduate degrees awarded in the time period under study. The Engineering numbers are 604 graduates or 2.49 percent for a total of all STEM graduates of 1871 degrees or 7.71 percent.

Engineers have lower Verbal SAT scores than the school average, higher Math SAT scores, comparable High School averages, and present fewer AP credits when they appear. (This latter may be the result of many Engineering students receiving their earlier education in foreign schools which do not offer AP course work, but this is speculation.) Engineers have a higher percentage of Asian students but lower percentages of Blacks and Hispanics and a far lower percentage of women (13 versus 54) than the school as a whole.

Non Engineering STEM graduates have profiles quite close to that of the Non-STEM student in all of the dimensions presented. Initially, we started out considering the fields of Biology, Chemistry, and Physics. Data for the freshman cohorts, 1997 to 2003 and how these students proceeded through their college career is given in Table 2. These STEM courses are probably fulfilling educational distributional requirements in the main; only 873 students over eight years of entrants or 5.6 percent of the students who initially declared one of these three fields as their major, graduated in that major.

[21] As would be expected, English majors excel in Verbal SAT scores, and have 71 percent women, almost 1.5 times higher than the whole school and over 5 times more than engineering. The final GPA is of interest with the English majors having a much higher final GPA than either STEM group and Economics.

In summary, engineers present lower ability scores (except for math) than other STEM graduates, are more likely to be a transfer student, and graduate fewer women and non-Asian minorities.

Other STEM graduates are much closer to their non-STEM peers. And both groups reflect a considerable reduction in number from those intending to be a STEM graduate and their achievement.

We have found that about 50 percent of the incoming engineering majors switch out of engineering. There are virtually no students who switch from some other field into engineering. This may be because the engineering programs precede lock step through a curriculum leaving little room for electives and the STEM courses build upon each other in the sequence.

Binghamton appears to have few STEM majors but many STEM courses are taken by non-STEM students to fulfill distribution requirements. The Harpur College Bulletin states; “Harpur students must complete additional requirements designed by Harpur College of Arts and Sciences to compliment and extend the general education requirements and further their liberal arts education. These requirements include: two courses in the Division of Humanities, two courses in the Division of Science and Mathematics, two courses in the Division of Social Sciences, and an additional four liberal arts courses chosen from each of the two divisions outside the division of the student's major department.“ Therefore all students are taking some STEM course work and the Non-Engineering STEM departments are serving these distributional requirements. This is compounded as the Engineering School also requires course work in math Chemistry and Physics, again increasing the distributional loading in these STEM departments[22].

[22] The Engineering school requires the following Non-Engineering STEM courses for Electrical Engineering: Calculus I , Chem. 111 Chemical Principles , Calculus II, PHYS 131 General Physics I, Math 371 Ordinary Differential Equation, Phys 132 General Physics II, and Math 323 Multivariable Calculus

V HYPOTHESIS TESTED

The Hypothesis we were able to test include:

1. Correlates of successful outcomes as measured by GPA or degree awarded do not vary between STEM and Non-STEM majors.
2. STEM majors and Non-STEM do not differ in preparation, gender, or ethnicity.
3. The Instructor’s gender makes no difference

A number of hypotheses were also tested but we found many of these tests to yield inconclusive results because of the absence of sufficient observations. For example, we looked at how the ethnicity of the faculty was related to the drop-out rate but such data on ethnicity are only collected for recent years and the drop-out rates seem to be more strongly related to grades. Of course there may be multicollinearity, but grades appear to be more important than ethnicity in our data.

Another hypothesis was that STEM courses have higher grading standards and this is discouraging to students. We can show the answer is yes, the average grades are lower for STEM courses but cannot relate this to encouragement or discouragement of students. It is well known that Economics departments grade harder than English Departments, yet there are majors in both fields, and we have no measure of encouragement in this case either.

Several other hypotheses we attempted to test included: students’ interests are awakened by intro courses; lack of preparation for STEM work; and AP courses may build over-confidence. The tests we were able to devise for these also were inconclusive.

VI MODEL POSTULATED

The paper tests if STEM majors who have different correlates of graduation rates and GPA than non-stem majors with respect to the following explanatory variables

- SAT Verbal Score
- SAT Math Score
- High School GPA
- Advanced Placement Grades
- Fulltime or Part-time status
- Gender
- Ethnicity

The graduation dependent variable is a binary variable, 1 for graduation and 0 for non-graduation within six years of entering the university. The GPA dependent variable is a continuous variable in the range 0 to 4.0.

The basic model for tests of outcomes uses a fixed effects estimator. This model is specified as follows:

Eq. (1) $$y^*_{itjh} = \alpha + x'^*_{itjh}\,\beta + \varepsilon^*_{itjh}$$

Where i denotes the individual student, t denotes the academic level of the student, j denotes the course, and h denotes the high school of the student. We define

$$y^*_{itjh} \equiv y_{itjh} - \bar{y}_{itj}$$

$$x^*_{itjh} \equiv x_{itjh} - \bar{x}_{itj}\text{, and}$$

$$\varepsilon^*_{itjh} \equiv \varepsilon_{itjh} - \bar{\varepsilon}_{itj}\,.$$

Here $\bar{y}_i, \bar{x}_i, and \bar{\varepsilon}_i$ are the average observations of the h-th individual student's high school averaged over all high school observations. Hence, y^*_{tijh} is the individual student's deviation from the mean of students from the relevant high school, etc. This is a fixed effects model that estimates intercepts for each high school. Y, the dependent variable, denotes the undergraduate GPA at various stages of the college career, or the awarding of a degree, etc. X denotes a vector of explanatory variables, and epsilon is an error term.

In general, unless stated otherwise, the fixed effect is the high school of the individual student. This method reduces heterogeneity that arises from such things as size of high school, area of the country, and possibly, to some degree, the parental economic status.

VII ECONOMETRIC RESULTS

We first investigated the issue of success by denoting GPA as the dependent variable[23] using all students as the population, where the number of observations is 44, 045 (see Table 3). Using a fixed effects mode[24] in SAS, we tested a version of equation (1). There are two models presented in Table 3 differing in the number of explanatory variables. Model 1 includes the issuance of a bachelor's degree, deg1 and is the better model in terms of fit[25]. All of the estimators are statistically significant by a t-test statistic. We found that women do better than men (coefficient is the second largest in value at 0.1386), entering as a freshman advantageous as are prior ability as shown in SAT and AP scores. Blacks, Hispanics and Asians are at a disadvantage and STEM students are also seen to be correlated with lower GPA. The basic difference between the results of

[23] Table A1 in the Appendix shows the results of using the end-of-term GPA for each student for each term enrolled. The results are similar as those of Model 2.

[24] Initially, we tried to analyze many issues using a Tobit procedure. We then looked at grades using ordered Logit, but were not certain the data met the proportionality assumption and indeed, there is evidence that the data probably violated this assumption (See Kokkelenberg, Dillon and Christy, 2007). Thus, we used a fixed effects model.

[25] While the differing number of observations makes a strict comparison via log likelihood Chi squared test uncertain, as the sample size approaches infinity, the likelihood ratio approaches Chi squared and this forms the basis for an approximate statistical test. In our case, the differences in the sample size are 0.63%, 44324 versus 44045 observations. The less restricted model is better by a Chi squared test; the calculated value is 12535 whereas the critical value is about 8 for one degree of freedom at the 99.5 % confidence level.

Model 1 and Model 2 are that allowing for the issuance of a degree reverses the negative sign on the correlation between GPA and STEM majors (Engineers and non-engineering STEM).

We next ran parallel fixed effects analysis for STEM students and those results are given in Table 4. In these cases, the degree variable was insignificant so the runs shown did not include that explanatory variable. In all three of these STEM results, the relative size of the estimators is about the same as shown in Table 3. However, the correlation between women and GPA weakens and becomes statistically insignificant as we look at more detail. In other words, the advantage women hold as shown in Table 3 disappears for STEM fields. The negative correlation between GPA and the ethnic groups also disappears as the estimators become insignificant. Prior ability as denoted by the SAT and AP variables continues to be strongly correlated with success in STEM courses, though SAT becomes statistically insignificant for engineering students. The reader should note that as Table 4 indicates, we have data on over forty four thousand students. The number of STEM students is a small fraction at 1871, and 604 of these are Engineering students.

The results of a further parallel analysis for all Non-STEM students was explored and we found that model 2 is better, all the estimators with the exception of that for freshman in Model 2 are significant, and the results are basically the same; ability is important, and ethnic groups are negatively correlated with GPA.

One of the chief conclusions from this analysis is that after allowing for the student's background as proxied by the high school, ability is important regardless of discipline in terms of final GPA. Any advantage that women have is confined to the Non-STEM fields, and blacks, Hispanics, and Asians are disadvantaged.

We next ran comparative fixed effects models to investigate the factors that correlate with getting an Engineering degree and a Non-Engineering STEM degree. These results are discussed next, and are shown in Tables 5 and 6.

In Table 5, we look at the correlation of the initial declaration of a major with receiving an Engineering degree[26]. While the explanatory variables are for the most part the same as those of earlier Tables, here we include the student's choice of first and second major. Using the log likelihood value, we see that the regression with 'freng', the first major choice, is the best explanatory model. Thus, students who major in graduate in engineering start their academic career by majoring in Engineering.

Finally, we calculated elasticities for these models and data. Note that we interpret these as response percentages, similar to the economist's term elasticity. Table 7 and 8 report the change in response of cumulative GPA for all, Non-STEM, and STEM students. STEM students' grades were more responsive to having entered as freshman, more responsive to math scores and AP course hours, than were Non-STEM students. But the difference between Engineers and other STEM students is shown in Table 8. Here we see a one percent change in math scores results in a 0.569 percent change in graduation///grades for engineers, but a very small, almost nonexistent, result for non Engineers. Again, it appears that STEM students need to concentrate on math skills and not verbal ones.

The authors decided to test the conclusion of "Mathematical Self-Concept: How College Reinforces the Gender Gap" by Linda J. Sax (1994) which pointed out that prevalence of female students in campus improves mathematical self concept among female students in mathematics courses. This idea was tested for Biology and Math courses to see if greater percentage of women in a class helped improve individual course grades. The variable "percentage of female students in a course" was introduced across all course levels in a regression model for grades (See Tables 9 and 10). It was found to be significant and positive at particular all course levels, except at 300 level math courses. Interaction terms of the percent female variable with gender of instructor and with gender of student were not found to be significant. Therefore there is a gender peer effect working, which shows that having more females in a class, improves a student's individual performance in a class irrespective of gender. The reason behind the gender

[26] Most Arts and Sciences Students at Binghamton defer the choice of a major until their fourth semester or beyond. Often, they are experimenting and searching and switch majors frequently. This appears not to be the case for STEM students.

peer effect could be the fact that female students perform better than male students, as the gender of the student variable is significant and positive.

Even though having female faculty or the student being a female improves the student's performance, their joint effect was not found to be significant. We investigated grades which are one of the products of college education and even if female instructors do not provide extra encouragement especially to female students when it comes to grades, they may provide other forms of encouragement – counseling and career advice which is not captured in this study. Gender peer effect was found to be significant for Biology and Math courses, i.e. having greater percentage of women in a class will raise the average performance of the class (except for 300 level Math courses).

The degree choice model has AP credits as one of the explanatory variables which controls for Advanced Placement Program's experience of students. AP credits are the total number of credits given to a student once he or she declares the AP exams taken and the respective grades on them. A student can take AP exams in STEM fields-Physics, Biology, Mathematics, Chemistry, Statistics, and Computer Science and also in Non-STEM fields-Literature, History, Music, Psychology, Art Studio and Economics. The number of STEM AP exams and non-STEM AP exams given by student can enhance interest or disinterest in STEM fields. To understand the correlation of number of STEM and Non-STEM Advanced Placement exams taken and degree major choice, the regression model for degree choice is modified to include two new explanatory variables in place of the AP credits variable (See Table 11). The two new explanatory variables are

a. STEM_AP=Number of STEM AP exams reported by student

b. Non-STEM_AP=Number of Non-STEM AP exams reported by student.

These two variables were significant in the degree choice models with opposite signs. Taking larger number of STEM AP exams increased chances of graduating with an engineering or non-engineering STEM degree or a STEM degree. The opposite results hold if larger number of Non-STEM AP exams is taken. This is an indication that interest in STEM fields start at school level which inspires a student to take up more STEM AP courses and eventually graduate with a STEM degree from college.

Most STEM tracks at Binghamton require a fairly lock-step series of courses be taken. At any level of the student's career, he or she must take certain specified courses to prepare them for the next level of study, and enrollment in certain upper division level courses is restricted to those with the prerequisites and frequently to department majors. Hence it is important that a student follow the proscribed path of study and declare their major early in their career. We also, then, looked at the initial declaration of major to test how important this is.

It has been suggested that academics in STEM fields see their role, in part, to weed out incompetents and do so more strongly than academics of other fields. Teachers of STEM courses do not see a societal good in inept designers of vehicles, bridges, and manufactories. Hence, they challenge applicants to be motivated and competent. This would result in higher grading standards and practices in STEM fields, a testable hypothesis. But we cannot link this statistically as causal of excessive dropouts.

VIII DISCUSSION

After reviewing the rates at which students change majors, it is evident that these rates are varied. If we partition students into two groups, STEM and Non-STEM, we find differential rates of changing from either to the other with very few students embracing a STEM major after starting out as a Non-STEM student (similar to engineers). But the rate of switching out of a STEM field is high, over 50% in some of our data.

Hence, we postulate that success in a STEM field, success here defined as declaring STEM as a major and graduating from a STEM field, accrues to those who have been interested and studying and working in STEM fields from high school or even possibly grade school. Our data only allows us to test this very weakly using the presence of high school AP credits as evidence of early commitment to studying a STEM field.

IX CONCLUSION

The attributes of a successful STEM major at Binghamton can be summarized briefly. Engineers who have good math preparation, who enter engineering as a freshman, and are of Asian ethnicity have better chances of success. Women are few in numbers as engineers. All other STEM fields see less emphasis on math preparation, but far more on the presence of AP course work, and are not as rigorous in a lock-step program necessitating freshman entry. Women also seem to have the same presence in these other STEM fields as the whole university.

Future work to answer the question of why there is such a large drop-out rate from STEM majors nationally probably should consider survey methods to elucidate the answers from a large sample; econometrics may be less than useful given the data limitations we now have about the motivations to enter STEM and the reasons for dropping out.

This is No. 2 APPENDIX A

LITERATURE REVIEW ON DETERMINANTS OF ENGINEERING GRADUATION AND RETENTION

Author, Year, Journal/WP/Book	Main Research Question	Sample/Database	Left Hand Side Variables	Right Hand Side Variables	Econometric Methodology	Main Result
Zhang, Anderson, Ohland, Carter and Thorndyke , 2002, American Society for Engineering Education 2002 Conference	Factors that explain engineering student graduation and retention	Data on engineering students from engineering colleges in nine universities for the time period 1987-1998. Out of nine, two colleges provided information on students till year 2000.	Graduation in engineering degree program; Current enrollment in engineering degree program	High School GPA, SAT Math score, SAT Verbal score, Ethnicity, Citizenship Status, Gender	Multiple Logistic Regression was run separately for nine colleges.	High school GPA and SAT Math (SAT Verbal) correlated positively (negatively) with graduation and persistence. Gender was significant, but not positive or negative consistently for all colleges. Ethnicity and Citizenship status were more significant for retention relative to graduation.
Fleming, Engerman, Griffin	Students' motivation for	First year experiences of 36	Using unstructured ethnographic interviews, six persistence factors- family influence, financial			Interest in mathematics

2005, American Society for Engineering Education 2005 Conference	studying engineering; Students' satisfaction with engineering programs in terms of persisting in the degree.	Howard University engineering students of color collected as part of Longitudinal database (first three years of engineering study) of engineering students at Howard University, Colorado School of Mines, Stanford University and University of Washington.	motivation, mathematics and science proficiency, academic advising, quality of instruction and availability of faculty were found to be influencing a student's decision to persist in engineering. Survey questionnaire, structured and ethnographic interviews, provided quantitative perspective to the qualitative data.	and science and financial factors were found to be the most influencial factors in pursuing an engineering degree. Family influence was relatively less significant. Students were not satisfied with academic advising, but expressed satisfaction with quality of instruction and availability of faculty.
Eris, Chachra, Chen, Rosca, Ludlow, Sheppard and Donaldson, 2007, American Society for Engineering Education 2007 Conference	Provides preliminary findings of Persistence in Engineering (PIE) survey. The survey covered the educational pathway of students, so that it can point out	. The survey has been administered six times longitudinally (over six years) to 141 first-year engineering students across 4 universities. 76% of 141 students persisted in engineering	The survey construct has items on academic and professional persistence, sources of motivation (financial, family influence, social good, mentor or high school teacher influence), confidence in math and science skills, in professional and interpersonal skills, in solving open-ended problems; perceived importance of math and science, of professional and interpersonal skills; working style, knowledge of engineering profession, curriculum overload, academic disengagement, extra-curricular activities, interaction and satisfaction with academic facilities,	Non-persistent students were motivated to study engineering due to family pressures and financial factors relative to persistent students. Persisters in

	the factors that explain persistence in engineering degree.	program in the fourth year of the survey.	faculty and TAs			engineering have more confidence in math and science skills and are more likely to work in groups and engaged in academics.
Cain, Fleming, Williams and Engerman, 2007, American Society for Engineering Education 2007 Conference	The significance of personal motivation (doggedness) in terms of perseverance, tenacity and ability to stubbornly see through things in completion of engineering degree	60 engineering students from 4 universities participated in the survey for over 3 years.	The survey construct had items on commitment to finish engineering degree, reasons for the commitment levels; enjoyment, interest and satisfaction with the engineering program and future plans.			The longer the students persisted in engineering program, their doggedness grew, even though the students displaying such characteristics reduced in number from year 1 to year 3.
Alting and Walser, 2007, American Society for Engineering Education 2007 Conference	Prediction of Retention and Graduation in Engineering by student entry characteristics and academic performance in	Fall 1999 cohort of engineering students (freshman and transfer) of City College of New York were tracked till Fall 2006 to note retention in and attrition from School	Retention and Graduation in Engineering Degree	Gender, Amount of math in high school, SAT scores, Declaration of engineering major, accumulation of credits in	Discriminant analysis	For freshman students, taking calculus courses was found to be significant determinant for their future success, while

	college	of Engineering.		engineering courses in first two years, Grade in the first math course taken		for transfer students it is GPA from previous college. Entry characteristics and academic performance in the first two years of college determined retention and graduation in engineering

LITERATURE REVIEW ON DETERMINANTS OF CHOICE OF COLLEGE MAJOR

Author, Year, **Journal/WP/Book**	**Main Research Question**	**Sample**	**Left Hand Side Variable**	**Right Hand Side Variables**	**Econometric Methodology**	**Main Result(s)**
Staniec, J.F.O. Fall ’04, Eastern Economic Journal	Determinants of College Major Choice and their variation by gender and race.	NELS:1988	Categorical variable depicting major choice	Score on NELS Test, Gender, Race, Single parent household, Educational Qualification of Parents, Family Income, Expected Income returns from the major field, AP and college preparation of high school class	Multinomial Logit	Black Students are more likely to choose SEM majors relative to other races. Increase in math test quintile improves chances of taking up SEM major. No significant difference in major choice by gender. Expected Income returns variable was not significant.

Brainard, S.G. and Carlin, L. 1996, Alfred P.Sloan Foundation WIE Report	Determinants of Retention of women in SE fields.	Responses to survey questionnaire provided at the end of freshman, sophomore, junior and senior years to students who expressed desire to gain SE degrees at the beginning of freshman year.	Persistence in SE field	Enjoy science and math classes, career opportunities, positive influence of WIE, faculty/ TA and advisor, interest in course, acceptance in department, working or not, fulltime or not, influence of science classes, plan to work as engineer, attendance of conference and events, part of student societies, involved in WIE Big Sister program	Stepwise Logistic Regression	Perceived barriers appear overtime to students (by 4th and 5th year) and they are low grades, poor teaching and unapproachable faculty. Influence of advisor, acceptance by department, enjoyment of science classes, working during school year and registration status are factors responsible for persistence in the freshman and sophomore years
Cohoon, 2001, Communications of the ACM	Determinants of female retention in computer science major	Responses to survey questionnaire provided to female students pursuing computer science major, faculty and dean of computer science departments	Survey questions were asked on issues of gender composition of students, faculty turnover, faculty attitudes towards female students, mentoring and teaching quality of faculty and demographic composition of faculty; the kind of institutional support received from Dean's office and local job market conditions		Correlation	Characteristics and practices of CS departments determine female retention in computer science primarily among them is the gender composition of students.

Malgwi, Howe and Burnaby, 2005, Journal of Education for Business	Determinants of College Major Choice and how they vary by gender.	Response to survey questionnaire provided to undergraduate students in large northeastern business school	Major Choice	Interest in subject, Aptitude in subject, college's reputation, influence of parents and HS counselor/teacher, related subject in school, job opportunities, career advancement and level of pay from the major's field.	Correlation	Aptitude in subject is more important to women than men. Interest in subject is most determining factor across both genders. Career and job opportunities influenced changes in major choice. Reason's for changing major are find the previous major difficult and influence of college advisor.
Polachek, 1978, Industrial and Labor Relations Review	Do sex differences exist in college major choice?	Eckland Data for the 1950s period. RTI-NLS Survey Data for 1970s period.	Vector of dichotomous variables representing major choice ranging from business to engineering. Humanities is the reference group	Gender, Aptitude score, Number of semesters of high school math and science, Person's reading speed, Educational level of mother, Marital status, Percent of time not worked since school, person's expectation from college education	Multinomial Logit	Controlling for aptitude, family background and college expectations, the gender variable was significant. Males tend to major in engineering and business and females in educations, home economics and medical fields

						(which are less prone to atrophy).
Jacob, 1986, Journal of Higher Education	The influence of college environment on the choice of major by testing three hypotheses :- sex role reinforcement; liberalization and the external trends hypotheses	CIRP data on freshman class of 1966 and 1976 and graduating class of 1970 and 1980. ACE data on 1967-71 and 1978-82 cohort. NLS data on high school class of 1972.	Duncan's Index of Dissimilarity was calculated for freshman and graduating classes' intended majors and degree majors.			There was a decline in sex-segregation of majors fell from late 60s to late 70s with early part of 70s witnessing the steepest fall. The author attributed the decline to societal changes (external trend hypothesis). Business (education) was found to be the most male (female) dominated field of the period under

						study
Solnick, 1995, Industrial and Labor Relations Review	Do females in women colleges tend to choose (move away from) male (female)-dominated majors relative to females in co-ed colleges?	Data on anticipated and final majors of 1700 students at 8 women colleges and 818 female students at 7 co-ed colleges.	Difference in percentage of females in male and female-dominated majors across both kinds of institutions from entry (intended major) to graduation (final major). Categorization of majors (female vs male dominated) were made based on percentage of female students in major groups (education and social work, biological sciences, language arts literature, social sciences, mathematics engineering computer science, cultural studies and physical sciences).			Females in women college are more (equally) likely to leave (persist in) female (male) dominated majors compared to their peers in co-ed colleges. Women colleges were found to produce more (fewer) graduates in male (female)-dominated majors.
Turner and Bowen, 1999, Industrial and Labor Relations Review	Role of SAT scores in gender differences in college major choices.	Data on graduates of 1951, 1976 and 1989 entering cohorts across 12 institutions from College and Beyond Database.	Vector of dichotomous variables representing major choice ranging from economics to engineering. Humanities is the reference group.	Categorical variables depicting the range of SAT Math score and SAT Verbal score.	Multinomial Logit, Oxaca Decompositon. Regressions were run for male and female students separately and also across cohorts.	Shrinkage of (Increase in) gender gap between mid-1950s to late 1970s (1976 and 1989). SAT scores account for a small part of gender gap in college major choices.
Weinberger, 1999, Industrial	To what extend does mathematical content of a graduate's major determine gender	5025 white men and women part-time, no more than 30 years old, and employed fulltime	Logarithm of Hourly Earnings.	Categorical variable describing major choice. Mathematical content of college	Ordinary Least Squares	Mathematical Content variable explains the whole of gender gap in

Relations	gap in wages?	respondents from 1985 Survey of Recent College Graduates dataset.		major determined by GRE-Quantitative score earned by graduates of that major, Technical Major, Gender, Predegree and Postdegree experience, Hours worked per week, Average GPA		wages.
Song and Glick, 2004, Social Science Quarterly	Tests various hypothesis (assimilation, human capital, family capital and Holland's capital development theory) to find out determinants of college major choice among Asian-American students	Sample of 9202 respondents from NELS 1988 belonging to racial groups of Whites, Chinese, Filipinos, Koreans and Southeast Asians. 1993 College Placement Council Salary Survey.	Enrollment in Post-secondary Education in 1994; Average yearly starting salary offers based on different college majors.	Race, Mother's Education and Single Parent Household, Parental involvement and educational expectations, Child's educational expectation, academic achievement, nativity, language spoken at home, measure of self-esteem and locus of control.	Heckman Two-Step Estimation Procedure. Probit Regression and Ordinary Least Squares.	Little difference among Asian and White men. Chinese, Filipino and Southeast Asian women are more likely to choose lucrative college major than their white peers. Parental involvement and expectation loses significance once the individual enters college. Respondents with low expectation from college education likely to enroll in lucrative majors.

						Psychological factors influence men's choices of major.
Montmarquette, Cannings and Mabseredjian; 2002, Economics of Education Review	How does uncertainty in terms of succeeding in major, expected earnings after graduation and earnings alternative if the student fails to graduate determine major choice?	562 individuals from NLSY 1979 who were enrolled in college in May 1979. Scores on Armed Services Vocational Aptitude Battery Test (ASVABSC) administered to NLSY79 respondents. Regression coefficient estimates from Rumberger and Thomas (1993) study on economic returns to college majors.	Graduation in Major Field; Choice of major in fields-business, liberal arts, science, education	Gender, Race, ASVABSC Test score, Family Income, Educational qualification and occupation type of parents, Family Structure, Type of residence-rural/urban, Expected earnings in job from major field, Estimated probability of success in major field, earnings of graduates, Earnings alternative	Probit Regression to estimate probability of success (graduation) in major fields. Multinomial Logit for choice of major	Science field offers the highest earnings for men and women and education the lowest. Projected probability of success for males (females) is highest in science (education).Choice of college major depends on expected earnings from the major field and women (white) are influenced relatively to men (non-white).
Ware and Lee, 1988, American Educational Research Journal	Determinants of major choice in science field and how they vary by gender	2592 participants of High School and Beyond 1980 who were enrolled in college in 1982; reported declared/intended major and scored above 50th	HS characteristics, aptitude, behavior variables:- HS GPA, HS math achievement, HS math courses, HS	Personal, family background; High School characteristics, aptitude, behavior; High School course taking and achievement and College	Path Analysis using Ordinary Least Squares separately for females and males. Personal, family background and HS characteristics, aptitude, behavior	Major positive predictors of HS enrollment in science and math courses are positive attitude towards math, negative attitude towards verbal

		percentile on a composite measure of achievement taken in high school senior year.	Science Courses. College characteristics, attitude and behaviors :- Attending 4 yr college, extracurricular activities, importance of family, years of math, science, social science and english courses. Choice of Science or Non-Science Major.	characteristics, attitude and behaviors.	variables were regressed on HS course taking and achievement. Then the above three blocks of variables were regressed on college characteristics, attitude and behaviors. Finally the four blocks of variables were regressed on choice of science/non-science of major	areas and educational aspirations Advice from HS staff on college is an important predictor of math achievement for females in HS but negatively influences college choice of science major. Hispanic females were less likely to enroll in science courses and perform poorly in school math. High school preparation in science-taking courses, positive attitude towards math positively influences choice of science major for both sexes. Women placing high priority on family life are less likely to pursue science majors.

Maple and Stage, 1991, American Educational Research Journal	Determinants of major choice in quantitative (math/basic sciences, engineering) field and how they vary by gender and ethnicity	2456 black and white students from HSB 1980 who reported in 1984 a major field of study in either a 4-yr college or 2-yr college.	Field of study HS sophomores planned for college; Number of math and science courses taken in HS sophomore year; Plans for number of math and science courses to be taken in HS senior year; Academic or general track high school program; Declaring a quantitative major.	Parents Education, Internal Locus of Control, Parent's influence on student's decision, school's influence on student's decisions, standardized scores on five achievement tests and attitude towards mathematics. Number of math and science courses taken in HS. HS grades. Separate models were analyzed for black female, white female, black male and white male subgroups.	Analysis of Linear Structural Relationships (LISREL) using OLS. Similar to Path Analysis.	Field of study specified in HS sophomore year and number of math and science courses completed through senior year had significant and direct effect on major choice in college. Number of math and science courses planned in HS sophomore year determined number of courses taken in the senior year. Test scores influenced selection of HS program, math and science courses planned and high school grades. Father's education had a negative effect on field of study in college. Mother's education influenced HS program and

						grades for black females and males. Parents positively influenced HS sophomore plans to take math and science courses but the effect did not exist in choice of quantitative major in HS sophomore level. School officials influences HS plans but not college plans for both the male subgroups. Explanatory power of the model was least for white females, followed by white males, black females and black males.

APPENDIX B

VARIABLES

Data were constructed from several files from The State University of New York at Binghamton (SUNY), also known as Binghamton University. The data consist of 926759 observations, observations made at the student-course level, and include data from the fall of 1997 through spring 2007. The names and identification numbers of the individual students included in this study are suppressed to conform to US regulations and University rules. We have some 173 variables from the administrative and academic records from University and created several other ‘marker’ variables to differentiate academic fields of study etc.

The variables are listed in Appendix Table A and statistics for those variables used in the fixed effects models follow in Appendix Table B. There are also several Box Plots of the variables used in the final tests. Some of the more important variables are discussed below.

The data consist of four types of variables; demographic values, ability variables, higher educational academic performance variables, and educational environment variables.

- Demographic variables include: gender, entrance cohort, ethnicity, family income and home zip code.
- Ability variables include: High School, High School Average, SAT scores, Advanced Placement course work, entered as Transfer, TOEFL Score, entered as a freshman or transfer student and aid offers,
- Academic performance variables consist of: course grade for each course completed, cumulative grade point average, time to degree, awarding of degree and the field in which the degree is awarded.
- Educational environment variables include: Class size, department of course, department of major(s), department of degree, full vs. part time, sports variables, residency hall variables and instructor variables-gender and ethnicity of instructor.

<u>Gender</u>

The gender indicator is dichotomous. Prior research has shown males tend to graduate at lower rates than females; also, they take longer to graduate. This may contribute to the observed differences in both grades attained and in graduation rates among disciplines in higher education.

Full-time

The dichotomous indicator of students' enrollment as a full time student helps to discern among the type of student. Institutions of higher education serve many different populations and non-traditional populations tend to exhibit patterns of behavior that lead to higher attrition rates and longer time to degree. It is possible the greater the representation of full-time students in a discipline may help explain performance.

Average SAT Score (SAT)

College entrance exams are the strongest single predictor of academic success in higher education; such academically prepared students have higher retention and graduation rates and are measures of the student's ability. We have SAT Verbal Score (SATV) and SAT Math Score (SATM).

Ethnicity

Dichotomous dummy variables are used in the regression to identifiy students from the following ethnic groups:-

- Asian
- White Non-Hispanic
- Black
- Hispanic

Advanced Placement

The Advanced Placement variables are numerous and include: number of AP exams/test, fields of same, and test scores when taken for each AP test. As these are self reported and there often is no incentive to report on AP experience if the student does not plan to use any credits from them toward graduation in college, we often use the sum of AP scores from tests.

Imputation

In order to overcome a lacuna in the data, three series that had systematic missing values were filled in by imputation. Many students that came to the school could not present meaningful SAT scores or high school averages. These were predominantly students from other countries, principally Middle Eastern countries. We first estimated the sample mean and variance for each series of interest from the actual data in hand. The actual values for these three variables had limited ranges and fairly tight distributions. We next randomly sampled from a normal distribution with mean and variance equal to that of the observed data series and generated pseudo observations.

APPENDIX A

LITERATURE REVIEW ON DETERMINANTS OF ENGINEERING GRADUATION AND RETENTION

Author, Year, Journal/WP/Book	Main Research Question	Sample/Database	Left Hand Side Variables	Right Hand Side Variables	Econometric Methodology	Main Result
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Fleming, Engerman, Griffin	Students' motivation for	First year experiences of 36	Using unstructured ethnographic interviews, six persistence factors- family influence, financial			Interest in mathematics

2005, American Society for Engineering Education 2005 Conference	studying engineering; Students' satisfaction with engineering programs in terms of persisting in the degree.	Howard University engineering students of color collected as part of Longitudinal database (first three years of engineering study) of engineering students at Howard University, Colorado School of Mines, Stanford University and University of Washington.	motivation, mathematics and science proficiency, academic advising, quality of instruction and availability of faculty were found to be influencing a student's decision to persist in engineering. Survey questionnaire, structured and ethnographic interviews, provided quantitative perspective to the qualitative data.	and science and financial factors were found to be the most influencial factors in pursuing an engineering degree. Family influence was relatively less significant. Students were not satisfied with academic advising, but expressed satisfaction with quality of instruction and availability of faculty.
Eris, Chachra, Chen, Rosca, Ludlow, Sheppard and Donaldson, 2007, American Society for Engineering Education 2007 Conference	Provides preliminary findings of Persistence in Engineering (PIE) survey. The survey covered the educational pathway of students, so that it can point out	. The survey has been administered six times longitudinally (over six years) to 141 first-year engineering students across 4 universities. 76% of 141 students persisted in engineering	The survey construct has items on academic and professional persistence, sources of motivation (financial, family influence, social good, mentor or high school teacher influence), confidence in math and science skills, in professional and interpersonal skills, in solving open-ended problems; perceived importance of math and science, of professional and interpersonal skills; working style, knowledge of engineering profession, curriculum overload, academic disengagement, extra-curricular activities, interaction and satisfaction with academic facilities,	Non-persistent students were motivated to study engineering due to family pressures and financial factors relative to persistent students. Persisters in

	the factors that explain persistence in engineering degree.	program in the fourth year of the survey.	faculty and TAs			engineering have more confidence in math and science skills and are more likely to work in groups and engaged in academics.
Cain, Fleming, Williams and Engerman, 2007, American Society for Engineering Education 2007 Conference	The significance of personal motivation (doggedness) in terms of perseverance, tenacity and ability to stubbornly see through things in completion of engineering degree	60 engineering students from 4 universities participated in the survey for over 3 years.	The survey construct had items on commitment to finish engineering degree, reasons for the commitment levels; enjoyment, interest and satisfaction with the engineering program and future plans.			The longer the students persisted in engineering program, their doggedness grew, even though the students displaying such characteristics reduced in number from year 1 to year 3.
Alting and Walser, 2007, American Society for Engineering Education 2007 Conference	Prediction of Retention and Graduation in Engineering by student entry characteristics and academic performance in	Fall 1999 cohort of engineering students (freshman and transfer) of City College of New York were tracked till Fall 2006 to note retention in and attrition from School	Retention and Graduation in Engineering Degree	Gender, Amount of math in high school, SAT scores, Declaration of engineering major, accumulation of credits in	Discriminant analysis	For freshman students, taking calculus courses was found to be significant determinant for their future success, while

	college	of Engineering.		engineering courses in first two years, Grade in the first math course taken		for transfer students it is GPA from previous college. Entry characteristics and academic performance in the first two years of college determined retention and graduation in engineering

LITERATURE REVIEW ON DETERMINANTS OF CHOICE OF COLLEGE MAJOR

Author, Year, Journal/WP/Book	Main Research Question	Sample	Left Hand Side Variable	Right Hand Side Variables	Econometric Methodology	Main Result(s)
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Brainard, S.G. and Carlin, L. 1996, Alfred P.Sloan Foundation WIE Report	Determinants of Retention of women in SE fields.	Responses to survey questionnaire provided at the end of freshman, sophomore, junior and senior years to students who expressed desire to gain SE degrees at the beginning of freshman year.	Persistence in SE field	Enjoy science and math classes, career opportunities, positive influence of WIE, faculty/ TA and advisor, interest in course, acceptance in department, working or not, fulltime or not, influence of science classes, plan to work as engineer, attendance of conference and events, part of student societies, involved in WIE Big Sister program	Stepwise Logistic Regression	Perceived barriers appear overtime to students (by 4^{th} and 5^{th} year) and they are low grades, poor teaching and unapproachable faculty. Influence of advisor, acceptance by department, enjoyment of science classes, working during school year and registration status are factors responsible for persistence in the freshman and sophomore years
Cohoon, 2001, Communications of the ACM	Determinants of female retention in computer science major	Responses to survey questionnaire provided to female students pursuing computer science major, faculty and dean of computer science departments	Survey questions were asked on issues of gender composition of students, faculty turnover, faculty attitudes towards female students, mentoring and teaching quality of faculty and demographic composition of faculty; the kind of institutional support received from Dean's office and local job market conditions		Correlation	Characteristics and practices of CS departments determine female retention in computer science primarily among them is the gender composition of students.

Malgwi, Howe and Burnaby, 2005, Journal of Education for Business	Determinants of College Major Choice and how they vary by gender.	Response to survey questionnaire provided to undergraduate students in large northeastern business school	Major Choice	Interest in subject, Aptitude in subject, college's reputation, influence of parents and HS counselor/teacher, related subject in school, job opportunities, career advancement and level of pay from the major's field.	Correlation	Aptitude in subject is more important to women than men. Interest in subject is most determining factor across both genders. Career and job opportunities influenced changes in major choice. Reason's for changing major are find the previous major difficult and influence of college advisor.
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						(which are less prone to atrophy).
Jacob, 1986, Journal of Higher Education	The influence of college environment on the choice of major by testing three hypotheses :- sex role reinforcement; liberalization and the external trends hypotheses	CIRP data on freshman class of 1966 and 1976 and graduating class of 1970 and 1980. ACE data on 1967-71 and 1978-82 cohort. NLS data on high school class of 1972.	Duncan's Index of Dissimilarity was calculated for freshman and graduating classes' intended majors and degree majors.			There was a decline in sex-segregation of majors fell from late 60s to late 70s with early part of 70s witnessing the steepest fall. The author attributed the decline to societal changes (external trend hypothesis). Business (education) was found to be the most male (female) dominated field of the period under

						study
Solnick, 1995, Industrial and Labor Relations Review	Do females in women colleges tend to choose (move away from) male (female)-dominated majors relative to females in co-ed colleges?	Data on anticipated and final majors of 1700 students at 8 women colleges and 818 female students at 7 co-ed colleges.	Difference in percentage of females in male and female-dominated majors across both kinds of institutions from entry (intended major) to graduation (final major). Categorization of majors (female vs male dominated) were made based on percentage of female students in major groups (education and social work, biological sciences, language arts literature, social sciences, mathematics engineering computer science, cultural studies and physical sciences).			Females in women college are more (equally) likely to leave (persist in) female (male) dominated majors compared to their peers in co-ed colleges. Women colleges were found to produce more (fewer) graduates in male (female)-dominated majors.
Turner and Bowen, 1999, Industrial and Labor Relations Review	Role of SAT scores in gender differences in college major choices.	Data on graduates of 1951, 1976 and 1989 entering cohorts across 12 institutions from College and Beyond Database.	Vector of dichotomous variables representing major choice ranging from economics to engineering. Humanities is the reference group.	Categorical variables depicting the range of SAT Math score and SAT Verbal score.	Multinomial Logit, Oxaca Decompositon. Regressions were run for male and female students separately and also across cohorts.	Shrinkage of (Increase in) gender gap between mid-1950s to late 1970s (1976 and 1989). SAT scores account for a small part of gender gap in college major choices.
Weinberger, 1999, Industrial	To what extend does mathematical content of a graduate's major determine gender	5025 white men and women part-time, no more than 30 years old, and employed fulltime	Logarithm of Hourly Earnings.	Categorical variable describing major choice. Mathematical content of college	Ordinary Least Squares	Mathematical Content variable explains the whole of gender gap in

Relations	gap in wages?	respondents from 1985 Survey of Recent College Graduates dataset.		major determined by GRE-Quantitative score earned by graduates of that major, Technical Major, Gender, Predegree and Postdegree experience, Hours worked per week, Average GPA		wages.
Song and Glick, 2004, Social Science Quarterly	Tests various hypothesis (assimilation, human capital, family capital and Holland's capital development theory) to find out determinants of college major choice among Asian-American students	Sample of 9202 respondents from NELS 1988 belonging to racial groups of Whites, Chinese, Filipinos, Koreans and Southeast Asians. 1993 College Placement Council Salary Survey.	Enrollment in Post-secondary Education in 1994; Average yearly starting salary offers based on different college majors.	Race, Mother's Education and Single Parent Household, Parental involvement and educational expectations, Child's educational expectation, academic achievement, nativity, language spoken at home, measure of self-esteem and locus of control.	Heckman Two-Step Estimation Procedure. Probit Regression and Ordinary Least Squares.	Little difference among Asian and White men. Chinese, Filipino and Southeast Asian women are more likely to choose lucrative college major than their white peers. Parental involvement and expectation loses significance once the individual enters college. Respondents with low expectation from college education likely to enroll in lucrative majors.

						Psychological factors influence men’s choices of major.
Montmarquette, Cannings and Mabseredjian; 2002, Economics of Education Review	How does uncertainty in terms of succeeding in major, expected earnings after graduation and earnings alternative if the student fails to graduate determine major choice?	562 individuals from NLSY 1979 who were enrolled in college in May 1979. Scores on Armed Services Vocational Aptitude Battery Test (ASVABSC) administered to NLSY79 respondents. Regression coefficient estimates from Rumberger and Thomas (1993) study on economic returns to college majors.	Graduation in Major Field; Choice of major in fields- business, liberal arts, science, education	Gender, Race, ASVABSC Test score, Family Income, Educational qualification and occupation type of parents, Family Structure, Type of residence- rural/urban, Expected earnings in job from major field, Estimated probability of success in major field, earnings of graduates, Earnings alternative	Probit Regression to estimate probability of success (graduation) in major fields. Multinomial Logit for choice of major	Science field offers the highest earnings for men and women and education the lowest. Projected probability of success for males (females) is highest in science (education).Choice of college major depends on expected earnings from the major field and women (white) are influenced relatively to men (non-white).
Ware and Lee, 1988, American Educational Research Journal	Determinants of major choice in science field and how they vary by gender	2592 participants of High School and Beyond 1980 who were enrolled in college in 1982; reported declared/intended major and scored above 50^{th}	HS characteristics, aptitude, behavior variables:- HS GPA, HS math achievement, HS math courses, HS	Personal, family background; High School characteristics, aptitude, behavior; High School course taking and achievement and College	Path Analysis using Ordinary Least Squares separately for females and males. Personal, family background and HS characteristics, aptitude, behavior	Major positive predictors of HS enrollment in science and math courses are positive attitude towards math, negative attitude towards verbal

		percentile on a composite measure of achievement taken in high school senior year.	Science Courses. College characteristics, attitude and behaviors :- Attending 4 yr college, extracurricular activities, importance of family, years of math, science, social science and english courses. Choice of Science or Non-Science Major.	characteristics, attitude and behaviors.	variables were regressed on HS course taking and achievement. Then the above three blocks of variables were regressed on college characteristics, attitude and behaviors. Finally the four blocks of variables were regressed on choice of science/non-science of major	areas and educational aspirations Advice from HS staff on college is an important predictor of math achievement for females in HS but negatively influences college choice of science major. Hispanic females were less likely to enroll in science courses and perform poorly in school math. High school preparation in science-taking courses, positive attitude towards math positively influences choice of science major for both sexes. Women placing high priority on family life are less likely to pursue science majors.

Maple and Stage, 1991, American Educational Research Journal	Determinants of major choice in quantitative (math/basic sciences, engineering) field and how they vary by gender and ethnicity	2456 black and white students from HSB 1980 who reported in 1984 a major field of study in either a 4-yr college or 2-yr college.	Field of study HS sophomores planned for college; Number of math and science courses taken in HS sophomore year; Plans for number of math and science courses to be taken in HS senior year; Academic or general track high school program; Declaring a quantitative major.	Parents Education, Internal Locus of Control, Parent's influence on student's decision, school's influence on student's decisions, standardized scores on five achievement tests and attitude towards mathematics. Number of math and science courses taken in HS. HS grades. Separate models were analyzed for black female, white female, black male and white male subgroups.	Analysis of Linear Structural Relationships (LISREL) using OLS. Similar to Path Analysis.	Field of study specified in HS sophomore year and number of math and science courses completed through senior year had significant and direct effect on major choice in college. Number of math and science courses planned in HS sophomore year determined number of courses taken in the senior year. Test scores influenced selection of HS program, math and science courses planned and high school grades. Father's education had a negative effect on field of study in college. Mother's education influenced HS program and

						grades for black females and males. Parents positively influenced HS sophomore plans to take math and science courses but the effect did not exist in choice of quantitative major in HS sophomore level. School officials influences HS plans but not college plans for both the male subgroups. Explanatory power of the model was least for white females, followed by white males, black females and black males.

APPENDIX B

VARIABLES

Data were constructed from several files from The State University of New York at Binghamton (SUNY), also known as Binghamton University. The data consist of 926759 observations, observations made at the student-course level, and include data from the fall of 1997 through spring 2007. The names and identification numbers of the individual students included in this study are suppressed to conform to US regulations and University rules. We have some 173 variables from the administrative and academic records from University and created several other 'marker' variables to differentiate academic fields of study etc.

The variables are listed in Appendix Table A and statistics for those variables used in the fixed effects models follow in Appendix Table B. There are also several Box Plots of the variables used in the final tests. Some of the more important variables are discussed below.

The data consist of four types of variables; demographic values, ability variables, higher educational academic performance variables, and educational environment variables.

- Demographic variables include: gender, entrance cohort, ethnicity, family income and home zip code.
- Ability variables include: High School, High School Average, SAT scores, Advanced Placement course work, entered as Transfer, TOEFL Score, entered as a freshman or transfer student and aid offers,
- Academic performance variables consist of: course grade for each course completed, cumulative grade point average, time to degree, awarding of degree and the field in which the degree is awarded.
- Educational environment variables include: Class size, department of course, department of major(s), department of degree, full vs. part time, sports variables, residency hall variables and instructor variables-gender and ethnicity of instructor.

<u>Gender</u>

The gender indicator is dichotomous. Prior research has shown males tend to graduate at lower rates than females; also, they take longer to graduate. This may contribute to the observed differences in both grades attained and in graduation rates among disciplines in higher education.

Full-time

The dichotomous indicator of students' enrollment as a full time student helps to discern among the type of student. Institutions of higher education serve many different populations and non-traditional populations tend to exhibit patterns of behavior that lead to higher attrition rates and longer time to degree. It is possible the greater the representation of full-time students in a discipline may help explain performance.

Average SAT Score (SAT)

College entrance exams are the strongest single predictor of academic success in higher education; such academically prepared students have higher retention and graduation rates and are measures of the student's ability. We have SAT Verbal Score (SATV) and SAT Math Score (SATM).

Ethnicity

Dichotomous dummy variables are used in the regression to identifiy students from the following ethnic groups:-

- Asian
- White Non-Hispanic
- Black
- Hispanic

Advanced Placement

The Advanced Placement variables are numerous and include: number of AP exams/test, fields of same, and test scores when taken for each AP test. As these are self reported and there often is no incentive to report on AP experience if the student does not plan to use any credits from them toward graduation in college, we often use the sum of AP scores from tests.

Imputation

In order to overcome a lacuna in the data, three series that had systematic missing values were filled in by imputation. Many students that came to the school could not present meaningful SAT scores or high school averages. These were predominantly students from other countries, principally Middle Eastern countries. We first estimated the sample mean and variance for each series of interest from the actual data in hand. The actual values for these three variables had limited ranges and fairly tight distributions. We next randomly sampled from a normal distribution with mean and variance equal to that of the observed data series and generated pseudo observations.

APPENDIX C

Table C.1: Decriptive Statistics of Variables used in Regression Model

	Cumulative GPA	Entered as Freshman	SAT Verbal	SAT Math	AP Credit Hours	Percent Female	Percent Black	Percent Hispanic	Percent Asian	Percent rec'v degree
Number of Observations	44324	44324	44324	44324	44324	44324	44324	44324	44324	44324
Location										
Mean	3.07	0.673	576.065	616.442	4.359	0.513	0.046	0.053	0.131	0.544
Median	3.08	1	580	620	0	1	0	0	0	1
Mode	2.67	1	600	650	0	1	0	0	0	1
Variability										
Std Deviation	0.490	0.469	87.255	81.999	6.986	0.500	0.211	0.224	0.337	0.498
Variance	0.240	0.220	7613	6724	48.807	0.250	0.044	0.050	0.114	0.248
Range	3	1	754.922	693.586	55	1	1	1	1	1
Interquartile Range	0.784	1	109.841	102.830	8	1				

Table C.2: Lower Division Course Grades

	Biology Grades			Chemistry Grades			Physics Grades			Math Grades		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Fall 1997	2018	2.6882	0.9255	1473	2.6907	1.0354	1037	2.8282	1.0753	1926	2.5088	1.1153
Fall 1998	1625	2.5582	0.9499	1360	2.7326	1.0435	1241	2.8728	1.0105	2124	2.3470	1.1659
Fall 1999	1559	2.6400	0.8933	1358	2.7172	1.0908	1241	2.7951	1.0692	2131	2.3276	1.1992
Fall 2000	1429	2.7437	0.9350	1380	2.8388	0.9999	1183	2.8085	1.0920	2174	2.3667	1.2163
Fall 2001	1149	2.6191	0.9746	1569	2.6886	1.0363	1468	2.9676	1.0044	2214	2.5734	1.1488
Fall 2002	1115	2.6495	0.9448	1411	2.8750	0.9966	1601	3.0453	0.9166	2238	2.4893	1.2175

Fall 2003	1405	2.6694	0.9064	1738	2.8324	0.9446	1493	2.9124	1.0417	2515	2.3884	1.2036

	T-Statistic for Difference in Mean Grades										
Fall 1997	Chem	Phy	Math	Fall 2000	Chem	Phy	Math	Fall 2003	Chem	Phy	Math
Bio	-0.0734	-3.5670	5.4829	Bio	-2.6035	-1.6097	10.4863	Bio	-4.9188	-6.7099	8.2468
Chem		-3.2021	4.9071	Chem		0.7301	12.5958	Chem		-2.2716	13.4507
Phy			7.6099	Phy			10.7506	Phy			14.5164
Fall 1998	Chem	Phy	Math	Fall 2001	Chem	Phy	Math				
Bio	-4.7369	-8.4754	6.1084	Bio	-1.7886	-8.9591	1.2094				
Chem		-3.4795	10.1596	Chem		-7.5345	3.2178				
Phy			13.7483	Phy			11.0040				
Fall 1999	Chem	Phy	Math	Fall 2002	Chem	Phy	Math				
Bio	-2.0723	-4.0961	5.0479	Bio	-5.8130	-10.8711	4.1880				
Chem		-1.8364	9.8928	Chem		-4.8585	10.4338				
Phy			11.7011	Phy			16.1358				

	Table C.3: Upper Division Course Grades											
	Biology Grades			Chemistry Grades			Physics Grades			Math Grades		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Fall 1997	1618	3.0685	0.9375	946	3.2029	0.9787	93	3.5892	0.4603	750	2.5425	1.1699
Fall 1998	1504	3.1234	0.8560	824	3.2398	0.8578	76	2.8737	0.9897	730	2.5460	1.1049
Fall 1999	1323	3.1085	0.8941	811	3.1572	1.0277	83	3.3675	0.6057	768	2.7116	1.0948
Fall	1610	2.9519	0.9963	925	3.1764	1.0962	83	3.1566	0.8303	886	2.7937	1.0885

2000												
Fall 2001	1772	3.0190	0.9047	1029	3.2425	1.0203	112	3.3509	0.6687	1103	2.8714	1.0399
Fall 2002	1640	3.1068	0.9192	970	3.1943	1.0222	109	3.4477	0.6397	980	2.8850	1.0642
Fall 2003	1916	3.0481	0.9322	1110	3.0671	1.1189	84	3.3298	0.8118	918	2.7331	1.0769

	T-Statistic for Difference in Mean Grades										
Fall 1997	Chem	Phy	Math	Fall 2000	Chem	Phy	Math	Fall 2003	Chem	Phy	Math
Bio	-3.4068	-9.8049	10.8080	Bio	-5.1308	-2.1679	3.5786	Bio	-0.4777	-3.0917	7.6023
Chem		-6.7360	12.3962	Chem		0.2021	7.4544	Chem		-2.7727	6.8304
Phy			16.3415	Phy			3.6962	Phy			6.2517
Fall 1998	Chem	Phy	Math	Fall 2001	Chem	Phy	Math				
Bio	-3.1333	2.1592	12.4250	Bio	-5.8208	-4.9723	3.8883				
Chem		3.1187	13.6980	Chem		-1.5326	8.3148				
Phy			2.7153	Phy			6.7999				
Fall 1999	Chem	Phy	Math	Fall 2002	Chem	Phy	Math				
Bio	-1.1164	-3.6540	9.3284	Bio	-2.1943	-5.2180	5.4255				
Chem		-2.7795	8.3285	Chem		-3.6453	6.5463				
Phy			8.4812	Phy			8.0308				

APPENDIX D

STEM Undergraduate Majors Available at Binghamton

Engineering

- Computer Science (4 majors)
- Electrical Engineering (7 majors)
- Mechanical Engineering (3 majors)
- Industrial Engineering (3 majors)

Non-Engineering STEM

- Biology (6 majors)
- Chemistry (6 majors)
- Environmental Studies (9 majors)
- Geology (9 majors)
- Mathematics (3 majors)
- Physics (4 majors)
- Psychobiology (2 majors)

APPENDIX D

STEM Undergraduate Majors Available at Binghamton

Engineering

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- Electrical Engineering (7 majors)
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Non-Engineering STEM

- Biology (6 majors)
- Chemistry (6 majors)
- Environmental Studies (9 majors)
- Geology (9 majors)
- Mathematics (3 majors)
- Physics (4 majors)
- Psychobiology (2 majors)

Table 1

Characteristics of Binghamton Students

Awarded Degrees

1997 through 2007

March 5, 2010

Degreed Students	**Nember of Degrees Awarded**	**Average SAT Verbal**	**Average SAT Math**	**Average HS GPA**	**Percent entered as Freshman**	**Number of AP credits**	**Percent Female**	**Percent Black**	**Percent Hispanic**	**Percent Asian**	**Average Final Cumulative GPA**
All	24251	571.12	614.14	91.69	0.68	4.48	0.54	0.04	0.05	0.14	3.22
Engineers	604	563.18	638.44	91.75	0.62	2.68	0.13	0.01	0.03	0.16	3.07
Non-Eng. STEM	1267	565.71	624.55	92.16	0.78	4.31	0.51	0.05	0.03	0.18	3.16
Chemistry	82	546.05	625.99	92.09	0.77	3.80	0.49	0.06	0.01	0.26	3.18
Economics	803	551.25	614.05	90.99	0.77	2.76	0.37	0.02	0.04	0.26	3.04
English	1049	581.03	582.77	90.97	0.73	2.88	0.71	0.05	0.06	0.09	3.30

Table 2.

Disposition of Non-Engineering, Non-Math STEM Students

Number of Students or Percent

					Presented No AP work			Presented AP Work			Total Students	
Field	Declare as first Major	Declare as second Major	Declare as Third Major		Took a course in this Field	Graduates in This Major		Took a course in this Field	Graduates in This Major		Took a course in this Field	Graduates in This Major
BIOLOGY	1336	122	3		3947	443		1251	237		5198	680
CHEMISTRY	209	46	4		4809	103		542	51		5351	154
PHYSICS	17	39	26		5141	28		690	11		5169	39
TOTALS	1562	207	33		13897	574		2483	299		15718	873

Table 3

Fixed Effects Model for All Binghamton Students1997 through 2007

Dependent Variable is Last Observed Cumulative GPA Fixed Effect is High School March 5, 2010

	Model 1			Model 2		
Variable	**Estimate**	**T Statistic**	**F value of Test of Fixed Effects**	**Estimate**	**T Statistic**	**F value of Test of Fixed Effects**
Intercept	2.301	107.09		2.577	114.09	
Freshman	0.012	2.68	7.2	0.008	1.67	2.8
SAT Verbal	0.0004	16.11	259.5	0.0003	10.49	110.1
SAT Math	0.0004	13.08	171.1	0.0003	10.1	102.1
AP Credits	0.015	44.00	1935.7	0.016	44.73	2000.8
Female	0.139	32.89	1081.5	0.165	36.78	1353.0
NonEngineering STEM Degree	-0.056	-4.37	19.1	0.101	7.67	58.8
Engineering Degree	-0.086	-4.72	22.3	0.082	4.32	18.7
Black	-0.192	-19.03	362.0	-0.208	-19.34	374.0
Hispanic	-0.129	-13.65	186.4	-0.158	-15.70	246.5
Asian	-0.071	-11.47	131.5	-0.058	-8.83	77.9
Rec'vd Degree	0.337	79.72	6354.6			
N	44045			44324		
Log Likelihood	50997			57264		
AIC	50999			57266		
AICC	50999			57266		
BIC	51007			57275		

Table 4

Fixed Effects Model for All BinghamtonNon STEM Students 1997 through 2007

Dependent Variable is Last Observed Cumulative GPA Fixed Effect is High School March 5, 2010

	Model 1			Model 2			
Variable	Estimate	T-Statistic	F value of Test of Fixed Effects	Estimate	T-Statistic	F value of Test of Fixed Effects	
Intercept	2.300	104.85		2.581	0.02314	111.6	
Freshman	0.012	2.53	6.4	0.008	0.005095	1.5	
SAT Verbal	0.0004	15.87	251.8	0.0003	0.000028	10.1	
SAT Math	0.0004	12.63	159.4	0.0003	0.000031	9.6	
AP Credits	0.015	43.3	1874.6	0.016	0.000364	44.0	
Female	0.142	33.05	1092.3	0.169	0.004586	36.9	
Black	-0.195	-18.89	357.0	-0.212	0.01102	-19.2	
Hispanic	-0.130	-13.48	181.8	-0.160	0.01028	-15.6	
Asian	-0.072	-11.19	125.1	-0.058	0.006837	-8.4	
Rec'vd Degree	0.337	79.37	6299.5				
N	42250			42453			
Log Likelihood	49175			55298			
AIC	49177			55301			
AICC	49177			55301			
BIC	49185.6			55309			