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Keywords

science, technology, engineering, mathematics, STEM, higher education, grades, performance

Comments

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The Importance of Grades and Pre-Collegiate Preferences

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Abstract

There is widespread concern, both in the private and public sectors, about perceived declines in U.S. college graduates in STEM fields. In our sample, the proportion of science majors has remained steady over the sample period; however, the number entering our college intending to major in STEM fields has fallen. In this paper we use administrative data from the graduating classes of 2001-2009, roughly 5000 graduates, from a northeastern liberal arts college to model the progression of students through STEM majors. A series of selection models predicts the choice of whether to take a second course in the department, conditional upon having taken a first course. This choice is modeled as a function of pre-college characteristics and preferences, characteristics of the student, the course, the professor, the peers in the course, and the grade received in the course. Using the selected sample that progresses to a second course, the choice to progress to a third is modeled conditional on having taken the second. The covariates in these models are similar to those in the first stage. Models are estimated for the Biology, Chemistry, Computer Science, Geology, Mathematics, Physics, and Psychology majors. Results suggest that gender effects are important, both in terms of the influence of the absolute and relative grades received, and in some cases in terms of the peers in the course and the gender of the instructor. The intended major (as reported on the admissions application) is a strong indicator of the likelihood of taking initial courses in a discipline and progression to a second course. AP credits are also strongly correlated to taking a first course, but diminish in the more selected samples. Grades and pre-collegiate intended major, have the most consistent and important influence on the decision to progress in a STEM major. When comparing across men and women, grades play a more important role in men's decision-making while preferences play a bigger role in women's choices.

1. Introduction and Background

For decades researchers and policy-makers have been concerned about the pipeline of graduates in science, technology, engineering, and mathematics (STEM) fields. Graduates in these fields are seen as a basic driving force behind international competitiveness, innovation, and productivity growth economy-wide. In an increasingly technical society, any gaps in the supply of and demand for technically trained workers and the continuing imbalances in the gender and race composition of these work forces present significant social and economic problems. Concerns about the number of graduates, the gender ratio of graduates, and the foreign ratio of graduates come to the forefront in discussions about the role of higher education in preparing students for the 21st century economy. A recent Higher Education Research Institute (HERI) research brief (HERI, 2010) highlighted the fact that even though the proportion of whites and underrepresented racial minorities (URM) interested in STEM fields has converged over the past 4 decades, their completion rates have continued to diverge. The attrition rates for STEM fields are high, and they are highest for URMs. In this study the determinants leading to attrition within STEM departments at a liberal arts college are examined. The results provide insights into why so many students begin college interested in STEM majors but far fewer complete one.

There is a broad literature examining major choice in higher education. One area focuses on the importance of early academic performance. There is significant evidence that relative performance in introductory courses is an important determinant of undergraduate major choice (Sabot and Wakeman-Linn (1991), Horvath, Beaudin, and Wright (1992), Dynan and Rouse (1997), Robb and Robb (1999), Chizmar (2000), Jensen and Owen (2001), Rask and Bailey (2002), and Rask and Tiefenthaler (2008). This literature is particularly important to an understanding of STEM major choice because in most colleges and universities STEM majors are among the lowest grading departments.

There is also a literature directly concerned with the trends in STEM majors. Along with introductory course performance, this literature highlights the importance of high school preparation and coursework, math aptitude, preferences for particular disciplines, career goals, and STEM course experiences as important factors in the choice of a STEM major (Maple and Stage, 1991; Ware, 1998; Daempfle, 2002; and Federman, 2007 and the literature cited therein). Both sets of literature suggest that major choice is a complex decision that is influenced by many different forces. Students come to college with expectations and abilities based upon their high school coursework, achievement, and parental and social influences. These expectations and abilities then collide with the collegiate science curriculum with its professors, labs, grades, and peers. When students take their first STEM course, all of these factors come together to alter their preferences and expectations and they decide whether to take another course. Eventually this sequence of decisions leads to a declaration of a major, sometimes within a STEM department, more often outside of the STEM majors.

In this paper I model this sequential decision-making process in an effort to quantify the important factors responsible for the high attrition rates in STEM majors. Because of the sample sizes these data are better for identifying attrition differences by gender than they are by race, so gender differences will be a focus of the analysis. Underrepresented minorities will be part of the analysis, but the small numbers do not allow them to be a focal point of the analysis. The paper is organized as follows. Section 2 contains background about the sample and descriptive data for important characteristics of the sample. Section 3 outlines the empirical methods and models, and Section 4 contains selected results from the estimations. Section 5 concludes.

2. Data, Attrition, and Factors Contributing to Attrition

2.1. Data Overview

The data for this study come from the administrative records of a small northeastern liberal arts college. Admissions records are combined with transcript records to create a consistent series following a student from admission to graduation (transfer students are excluded from this analysis). Graduation rates at this college have averaged about 90% over the sample period, so the attrition modeled here is not the usual college attrition that has a rich literature. Rather, here the within department attrition decision from STEM is modeled as a student progresses from a first course to a second, and a second to a third. The STEM departments at the college are comprised of Biology, Chemistry, Computer Science, Geology, Mathematics, Physics, and Psychology. The sample consists of 5,044 students from the graduating classes of 2001 through 2009. Women comprise 51% of the sample; however, the gender composition of the groups that take a first course in a STEM department are quite different. Only 31% of those taking a first computer science course are women compared to psychology, in which 61% of first-takers are women. In some departments the attrition is quite substantial. In computer science for example, fewer women take a first course, and by the fourth course only 17% are women. In psychology the opposite occurs, 61% of those taking a first course are women, and that number rises to 78% by the fourth course.

Table 1 gives the overall departmental attrition rates and an overview of the gender composition at each stage of the progression through the departments by showing the number of men and women and the proportion who take courses at each stage. The significant attrition in STEM departments is evident from the top panel of Table 1. For example, of the 5,044 eligible students in the sample, 1002 (20%) take a first computer science course. That number then drops to 268 (5%) taking a second course and falls to 3% of the total taking a fourth course. Another interesting characteristic from the top of Table 1 is the heterogeneity in actual attrition at the different stages of a major. In chemistry for example, the sample that takes introductory chemistry largely continues on to a second and a third course, 24% of the sample starts and falls to 17% at the second stage and then to 11% by the third. In geology the number starts higher with 34% taking a first course, but finishes much lower with only 3% left by the fourth course.

TABLE 1: ATTRITION, GENDER COMPOSITION, AND DEPARTMENTAL PROGRESSION

	Biology	Chemistry	Computer Science	Geology	Math	Physics	Psychology
Overall	5044	5044	5044	5044	5044	5044	5044
Introductory	1682 (33%)	1231 (24%)	1002 (20%)	1692 (34%)	3295 (65%)	748 (15%)	2211 (44%)
2nd Semester	822 (16%)	865 (17%)	268 (5%)	368 (7%)	1784 (35%)	491 (10%)	728 (14%)
3rd Semester	592 (12%)	554 (11%)	157 (3%)	183 (4%)	825 (16%)	176 (3%)	510 (10%)
4th Semester	488 (10%)	407 (8%)	130 (3%)	144 (3%)	460 (9%)	124 (2%)	475 (9%)
Men	2496	2496	2496	2496	2496	2496	2496
Introductory	740	536	695	875	1721	435	855
2nd Semester	343	360	215	230	1021	275	201
3rd Semester	247	224	129	98	514	123	120
4th Semester	193	170	108	77	301	86	106
Women	2548	2548	2548	2548	2548	2548	2548
Introductory	942	695	307	817	1574	313	1356
2nd Semester	479	505	53	138	763	216	527
3rd Semester	345	330	28	85	311	53	390
4th Semester	295	237	22	67	159	38	369
%-Women	51%	51%	51%	51%	51%	51%	51%
Introductory	56%	56%	31%	48%	48%	42%	61%
2nd Semester	58%	58%	20%	38%	43%	44%	72%
3rd Semester	58%	60%	18%	46%	38%	30%	76%
4th Semester	60%	58%	17%	47%	35%	31%	78%

Looking now at the bottom three panels in Table 1 there is significant heterogeneity in attrition across and within departments when one looks at numbers by gender. Some introductory courses are strongly imbalanced towards women (psychology at 61%) and others are more male-dominated (computer science at 69%). Some stay relatively constant throughout the progression (chemistry starts 56% female and is 58% by the fourth course), while others exhibit a very gendered attrition (math going from 48%→35% female and psychology going from 61%→78%). It is interesting that biology and chemistry show little difference in attrition rates by gender. These are some of the largest STEM fields and at this college they are female-dominated majors.

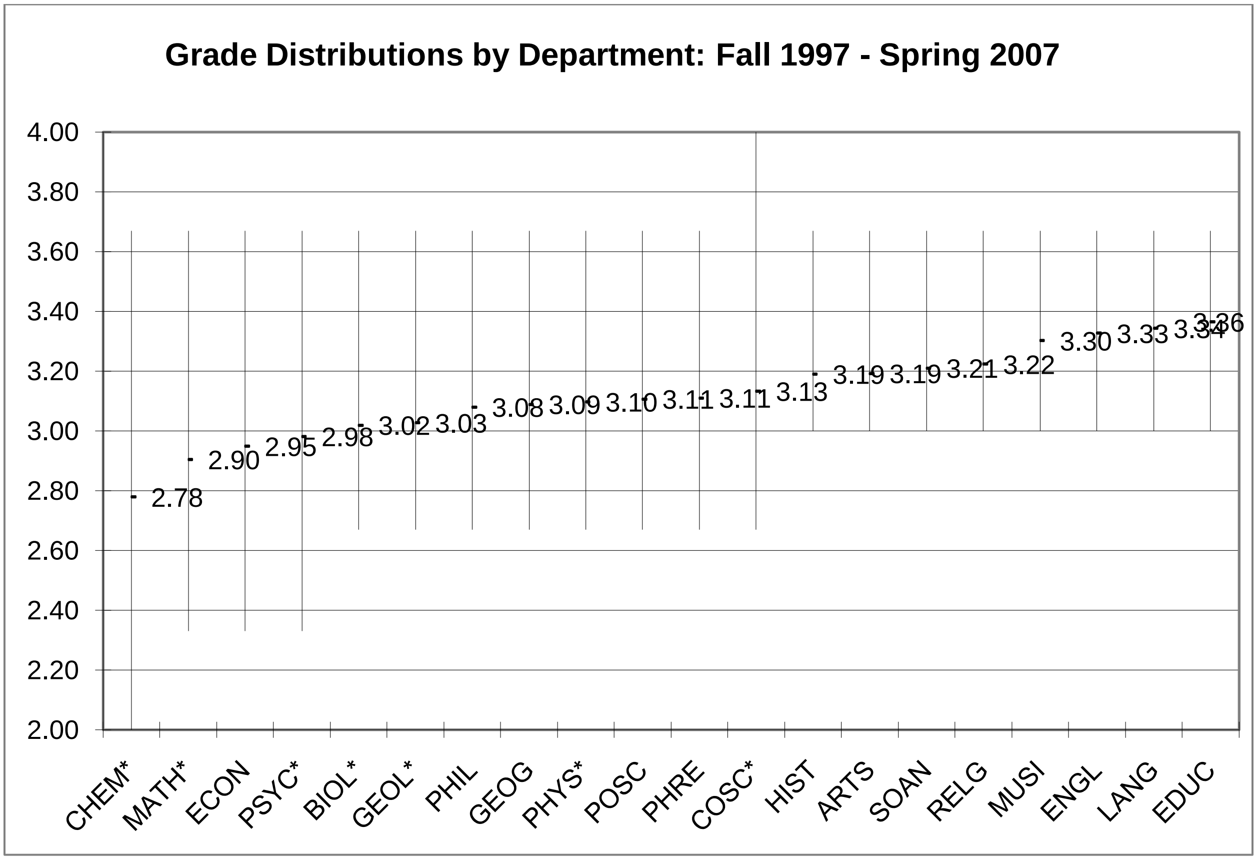
2.2. Grades in STEM Majors

In all of the literature on course choice and major choice the grade received in a course is an important factor in the decision to continue studying the subject. An equally important characteristic of major choice in STEM departments is that the grades given in the sciences are often among the lowest. Sabot and Wakeman-Linn (1991, p.168), after simulating major choice in their Williams College sample, said it best.

> *If the Math department adopted in its introductory course the English 101 grading distribution, our simulation indicated an 80.2 percent increase in the number of students taking at least one additional Math course!*

In my sample these relative grading relationships across departments hold as well. If STEM departments grade lower than non-STEM departments, and the grade received is an important factor in the major decision, grading practices could be an important factor in the high attrition rates experienced in STEM majors. Figure 1 illustrates the mean grade and the spread in grades across the departments in my sample.

FIGURE 1



When ordered from lowest to highest mean grade given over the sample period, all the STEM departments fall below the college mean. Additionally, 5 of the lowest 6 grading departments are STEM departments. These overall grading trends mask even larger grading differences in the lower-level and introductory courses. Across the board the introductory STEM courses are among the lowest grading courses on campus.

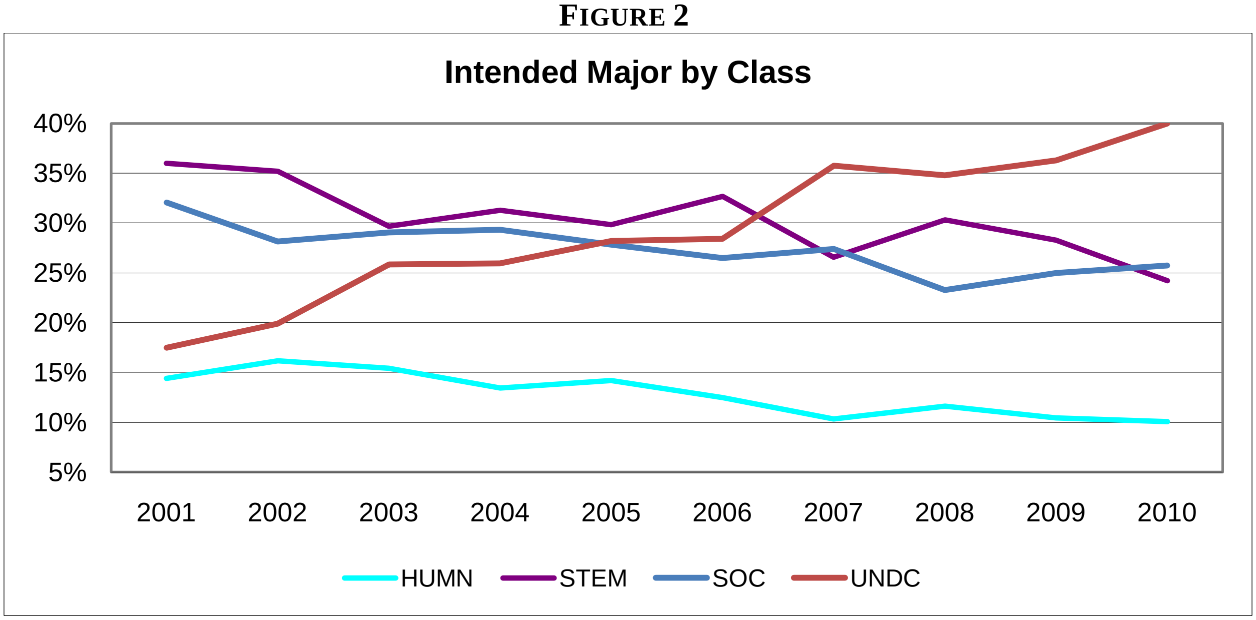
Relative grades are a second factor that could influence STEM attrition rates. If students are sensitive not only to the grade received in their STEM course but also to the grades received in their other courses, grade inflation/compression opens up another pathway by which students become less likely to pursue STEM courses. This could occur if non-STEM grades are inflating over time faster than STEM grades. For example, descriptive data from the sample suggest that

STEM grades are not only lower, but have not inflated as much as non-STEM grades over the sample period. This could exert another negative influence on the probability of taking more courses. The empirical setup below will test for the influence of STEM grades and non-STEM grades on the probability of taking another course.

2.3. Preferences for STEM Majors

The admissions records provide an important variable that gives some insight into the pre-collegiate major preferences of each student. In the application students are asked if they have a preference for a particular major, their intended major. Roughly two-thirds of matriculants report a specific field. If the intended majors numbers are falling it could be a contributing factor to the attrition illustrated above. Figure 2 illustrates the history of the preferences for STEM majors among the entering classes.

FIGURE 2



From these data it is evident that there has been a decline in the propensity of applicants to state a preference for any discipline; however, the largest decline has been among the STEM majors. In the class of 2001, 36% of the incoming first-years reported a STEM major as their intended major. By the class of 2010 that had dropped to 24%. It is unclear whether this is a function of high school seniors coming to college with less-pronounced preferences or whether they are just less likely to state them.

3. Methods

The variables highlighted above are combined with other individual and course-specific information in selection models of course choice in each of the seven STEM departments in the sample. While grades and pre-college expectations are of primary importance in this study, other factors are incorporated to account for abilities and preferences in course choice. To measure whether there has been any systematic increase or decrease in the desirability of a department a time variable is included in each model. How senior a student is when they take the course is included to control for the lower probability of continuation the later one takes the first course in a field. SATs, high school grades, and AP credits within the discipline account for specific math and English aptitudes along with general academic performance and discipline-specific pre-college courses. A variable measuring course size is included to test whether having bigger classes has a differential effect by gender. A simple instructor gender dummy and the proportion of women in the course are included to test whether there are role model effects or peer effects. A non-Asian dummy variable is included to test whether underrepresented racial minorities have different attrition rates. In response to high attrition rates, some STEM departments have offered new gateway courses separate from the traditional introductory science course. Among other motivations, these courses are intended to give an alternative entry point to the major for those students less sure about their interest in science or those less prepared upon entering college. In some of the models these courses will be flagged with dummy variables.

From the data presented in Table 1 it is clear that most of the attrition in the STEM departments occurs after the first or second course, as individuals who take a third course or more are very likely to major in the discipline. For that reason we first focus on models of course choice that predict taking a second course conditional upon having taken a first, and the choice to take a third course conditional on having taken the second. Equations 1 and 2 delineate the general form of the selection model estimated for the first stage decision in each department. These models are estimated separately for men and women because prior research has shown different sensitivities by gender to many of these influences on course choice.

$$\begin{aligned}P\,(2^{nd}) = A &+ \beta_1 Seniority + \beta_2 Class + \beta_3 SATm + \beta_4 SATv + \beta_5 HSGPA + \beta_6 MinorityNA \\ &+ \beta_7 IntroGrade + \beta_8 NonIntroGPA + \beta_9 IntendMajor \\ &+ \beta_{10} IntendPreMed + \beta_{11} IntendOtherScience + \beta_{12} IntendSocSci + \beta_{13} IntendHumn + \\ &+ \beta_{14} FemaleFac + \beta_{15} CourseSize + \beta_{16} \%Women + \beta_{17} AltIntro + \beta_{18} DeptAPs + \varepsilon_i\end{aligned} \tag{1}$$

$$\begin{aligned}P\,(Intro) = A &+ \alpha_1 GradClass + \alpha_2 SATm + \alpha_3 SATv + \alpha_4 HSGPA + \alpha_5 MinorityNA + \alpha_6 FinAid \\ &+ \alpha_7 IntendMajor + \alpha_8 IntendPreMed + \alpha_9 IntendScience \\ &+ \alpha_{10} IntendSocSci + \alpha_{11} IntendHumn + \alpha_{12} DeptAPs + \mu_i\end{aligned} \tag{2}$$

Of primary interest are the estimates for $\beta_7 - \beta_{13}$. The effect of the own course grade (β_7) and the grades in the other courses (β_8) will determine not only the sensitivity to the 'harder' grading scale in the STEM departments, but also whether the relative grade exerts an influence on the choice to pursue more courses in a department. The estimates for $\beta_7 - \beta_{11}$ will show how important pre-collegiate expectations and preferences for a discipline are and whether they continue to exert an influence after taking a first course.

The second stage models are probit models of the decision to take a third semester in a department conditional upon having taken the second. Initially selection models were estimated to check for selectivity bias in the samples. In all cases it was rejected, so probit models are used to model the choice to take a third semester in a department. These models are similar to Eq. 1

from above. Finally, as a complementary approach to looking at attrition, Section 3.4 contains the results of estimating a series of major choice equations for each STEM department. Four choice outcomes (No science major/Science major/particular STEM minor/particular STEM major) are modeled with an ordered probit equation where the covariates contain the background variables along with the course outcome variables from the first course in the department. These models are similar in type to those in the literature that explain major choice from a snapshot of data at a particular point in time.

4. Results

4.1. Grade Sensitivities

As expected, the grades received in a course are an important determinant of whether a student takes another course in the major. However, there are differences, both across departments and by gender, in terms of the responsiveness to grades and also whether the absolute grade or relative grades matter in the choice. Table 2 contains the partial probabilities from the estimations of progressing to a second and third semester in a department.

TABLE 2: INFLUENCE OF GRADES ON THE PROBABILITY OF PROGRESSION

	Biology	Chemistry	Computer Science	Geology	Math	Physics	Psychology
Progress to 2nd							
Men							
Course Grade	0.062**	0.149***	0.112***	0.026***	0.040**	0.095**	0.018**
Non-Course GPA	0.037	0.007	-0.077*	-0.050***	-0.007	-0.029	-0.005***
Women							
Course Grade	0.043**	0.072***	0.001	0.000	0.037**	0.134*	0.203
Non-Course GPA	-0.048	-0.048**	-0.046	-0.036	-0.057*	-0.006	-0.130
Progress to 3rd							
Men							
Course Grade	0.146***	0.203***	0.122***	0.133**	0.000	0.152	0.234***
Non-Course GPA	-0.008	-0.096	-0.175	-0.299***	0.054	0.157	-0.080
Women							
Course Grade	0.115***	0.276***	0.091	-0.003	0.010	0.131***	0.151***
Non-Course GPA	-0.046	-0.242***	0.240	0.081	0.024	-0.166**	-0.055

***=p-value<.01, **=p-value<.05, *=p-value<.10

From the results for men, both progression to a second semester and also a third, the grade received in the course is the most consistent and strongest influence on the decision to continue in the department. In biology, for example, a male who performs one grade higher is 6.2 percentage points more likely to take a second course. The grade in the second course has an even larger influence on the probability of taking a third, with an estimate of 14.6 percentage points for each higher grade received. Among the departments, chemistry grades generally have the biggest influence on both men and women, especially in the decision to take a third course. These results clearly suggest that higher grades in STEM courses would increase persistence rates throughout all the majors. The results for relative grades are less clear and not consistent across departments and gender. At each stage, in no more than two departments do men or women exhibit sensitivity to their grades received outside of the STEM course. While most of the estimates are in the expected direction, the effects are not consistently statistically significant.

In some cases sample size might be a factor, as there are so few women in computer science. However, the sub-sample sizes for math and physics appear large enough that if there were an influence it would be picked up. Another finding is that men appear to be more sensitive than women to the grades received in their STEM courses. Both in terms of statistical significance and also magnitudes, at both stages of progression the men's estimates are larger.

4.2. Pre-Collegiate Preferences

Using the information about expected major from the admissions file, dummy variables are constructed to capture whether the student intended to major in the particular STEM department, pre-Med (which the college doesn't have as a major), one of the other STEM majors, a social science or a humanities major. Those who didn't express a preference are the omitted group against which the estimates are compared. Table 3 contains the estimates of the influence of these preferences on the probability of taking a second course. Table 4 contains the estimates for taking a third course. Some of the cells in both tables are empty because estimates could not be generated because of collinearity, perfect prediction of the outcome, or no variation. Relatively few individuals intend to major in Geology upon entering this college, and even fewer of them are left a few courses into the sequence. In Table 4 these issues become more prevalent as the samples get smaller.

Table 3: Influence of Expected Major on Prob. of Progression to 2nd Course

	Biology	Chemistry	Computer Science	Geology	Math	Physics	Psychology
Men							
Department	0.356***	0.163***	0.309***	0.575***	0.150**	0.466***	0.321
Pre-Med	0.410***	0.160**	NA	0.007	NA	NA	0.149
Other Science	0.094	0.095*	0.041	-0.015	0.109***	0.169***	0.004***
Social Science	-0.190***	-0.174**	-0.031	-0.024**	-0.042	-0.180***	0.003***
Humanities	-0.037	0.164*	0.073	-0.014	-0.146**	-0.181**	0.026**
Women							
Department	0.391***	0.442***	0.341*	0.938***	0.228***	0.365***	0.272**
Pre-Med	0.419***	0.524***	NA	-0.084	0.137***	NA	-0.052
Other Science	0.150***	0.262***	-0.034	0.074	-0.078***	0.165**	0.012
Social Science	-0.140**	-0.114***	-0.033	-0.027	-0.088**	-0.168*	-0.131
Humanities	-0.097**	-0.072*	-0.007	-0.039	0.014*	-0.020	-0.118

***=p-value<.01, **=p-value<.05, *=p-value<.10

The influence of pre-collegiate preferences is quite consistent and strong for both men and women across STEM departments. The exception is introductory psychology men who intend to major in psychology. They don't have a higher likelihood of taking a second course. All other combinations are more likely to major in that department with an average effect around 30 percentage points. Unlike what I found with grade sensitivities, women appear to follow their preferences more strongly than men. Aside from physics, in the rest of the STEM departments the estimates for women are higher than men, in some cases much higher. Because the measure is a simple dummy variable, it could be that women hold stronger preferences entering college than men. However, given the data, I can't determine the underlying factor. The remaining rows containing the estimates for other intended majors most all take the expected sign. Pre-med intended majors are likely to continue in biology, chemistry, and math. These three disciplines have core requirements for medical school independent of an undergrads choice of major. Students who enter intending to major in a social science or humanities field are less likely to continue on past a first STEM course. Students filling distribution requirements in STEM departments are consistent with these findings.

Comparing the results reported in Table 3 to those in Table 4 below there is a general lowering of the influence of the intended major. This makes sense as the sample becomes more selected, the influence of pre-collegiate preferences should decline. When looking at the decision to progress to a third semester, only those who intended to major in biology and math are predicted to be more likely to continue on. Unlike the influence of grades, which persist in their importance over time, the influence of intended major doesn't extend much beyond the second course taken in a department. As a student progresses the collegiate experience shapes preferences more and the influence of high school experiences wanes.

TABLE 4: INFLUENCE OF EXPECTED MAJOR ON PROB. OF PROGRESSION TO 3RD COURSE

	Biology	Chemistry	Computer Science	Geology	Math	Physics	Psychology
Men							
Department	0.137***	0.001	-0.094	NA	0.196***	-0.082	-0.060
Pre-Med	0.223*	NA	NA	NA	NA	0.013	0.231
Other Science	0.047	NA	-0.0443	0.231**	-0.043	-0.243***	0.073
Social Science	0.001*	0.062	-0.123	-0.067	-0.094*	-0.337***	-0.042
Humanities	-0.417	-0.177	-0.055	-0.124	0.040	-0.275	-0.583***
Women							
Department	0.173***	0.004	-0.305	NA	0.338***	0.275*	-0.001
Pre-Med	0.109*	NA	NA	NA	NA	-0.066	0.218***
Other Science	0.075	NA	0.294	0.141	-0.061**	0.114	0.023
Social Science	-0.197*	-0.265**	0.320	-0.248*	-0.160**	-0.028	-0.251***
Humanities	0.002	0.080	NA	-0.475***	-0.204	0.127	-0.081

***=p-value<.01, **=p-value<.05, *=p-value<.10

4.3. Other Influences on Attrition

There are several interesting sets of results pertaining to the influence of the other controls in the models. Across all departments and stages the further along a student is when they take their first course the less likely they are to take a second. There aren't any clear time trends in terms of higher or lower likelihoods to take STEM courses in general. However, a couple of departments, biology (women) and chemistry and math (both), have become more popular over the sample period. More people are taking a first physics, geology, and computer science course in recent years. This is likely an outcome of curriculum revisions that have expanded the variety of offerings at the introductory level. However, these revisions could lead to another pattern that is evident for computer science and geology, where there are increased likelihoods of taking a first course, but lower likelihoods of progression to a second. In addition, the estimates for the influence of the first course taken being one of the new 'alternative' gateway courses in the department suggest that these courses have no impact on lowering attrition within STEM. The results for SATs closely followed expectations. In most departments math (verbal) SATs consistently predict higher (lower) likelihoods of taking a first and second course. These again become less important and less consistent as you move further along in a departmental curriculum. AP credits are also strong predictors of taking a first course, however the effect gets quite variable and wanes significantly when looking at second or third courses. I didn't find any broadly consistent influence of course size on attrition across all the departments. There was evidence that it mattered in biology and chemistry, but little else. I also didn't find pervasive evidence of role model effects. In some departments at some stages (biology, chemistry) there was evidence that women were more likely to progress if they had a female faculty member. There were also some instances where male professors showed an influence on male students. However, in most of the cases there was no measureable effect. The gender composition of the course failed to show any systematic relationship to the decision to take more courses for either men or women. Finally, I found very little evidence of non-Asian minorities being more or less likely to take additional STEM courses. In one or two cases they were more likely to take an introductory class, but not to take a second semester. In another they were no more likely to take an introductory course but were less likely to continue to a second.

4.4. Major Choice, Grades, & Pre-Collegiate Preferences

In this section I take an alternate approach to the issue of attrition by modeling the choice of whether to: 1) not major in a STEM field, 2) major in a STEM field outside of the department from which the introductory course is being taken, 3) minor in the department of the introductory course, and 4) major in the department of the introductory course. This is implemented as an ordered probit model where the dependent variable takes on the values from 0-4 and the covariates are the same measures used in Eq. 1 from above. These include aptitude measures, demographics, the grade in the course and the GPA received during the same semester outside of the introductory course, intended major, and the course characteristics from the introductory course. Table 5 contains selected results from the estimations for men and women.

TABLE 5: INFLUENCE OF GRADES & PREFERENCES ON PROBABILITY OF MAJORING

	Biology	Chemistry	Computer Science	Geology	Math	Physics	Psychology
1st Course Grades							
Men							
Course Grade	0.059***	0.029***	0.064***	0.046***	0.008***	0.066***	0.052***
Non-Course GPA	0.019	0.011	-0.036***	-0.033***	0.018***	0.040	-0.010
Women							
Course Grade	0.083***	0.032***	0.012*	0.029***	0.003**	0.027**	0.172***
Non-Course GPA	-0.038*	0.012	-0.019*	-0.022**	0.007***	0.026	-0.093***
Preferences							
Men							
Intended Major	0.252***	0.174***	0.185***	0.332**	0.087**	0.276***	0.100*
Pre-Med	0.455***	0.118**	0.174	0.206**	0.159***	0.167***	0.131*
Other Science	0.119***	0.050***	0.090***	0.092***	0.051***	0.056*	0.061***
Women							
Intended Major	0.279***	0.085*	0.042	0.976***	0.107***	0.094	0.146***
Pre-Med	0.211***	0.042	0.144	0.046	0.030**	0.042	0.129
Other Science	0.123***	0.037***	0.023	0.093***	0.029***	0.025	0.113***

***=p-value<.01, **=p-value<.05, *=p-value<.10

The results in the top panel of Table 5 largely mirror those from the semester by semester attrition models (Table 2) in both magnitude and sign. The grades received in the introductory course are associated with a higher probability of majoring in that department for men and women. The magnitudes of the effects are similar, but compared to Table 2 the differences between men and women aren't as great. Also, women are more likely to exhibit sensitivity to relative grades than men in these models.

The results in the bottom panel related to the pre-collegiate major preference are also similar in sign and significance to those from above but with a lower magnitude. Intended major is a strong predictor of actual major, especially for biology and geology. Both men and women who declare an interest in pre-Med are very likely to be biology majors, and the men also gravitate towards geology, math, and physics. There is also strong evidence of 'switching' among the science majors, as those who enter intending to major in some other STEM department outside of the introductory course department have a high probability of majoring in the different department. In sum, these results reinforce the results from the selection models but the gender patterns exhibited earlier don't hold as strongly. This is not surprising because the choice of a major is subject to more influences than the choice to take another course.

5. Conclusions

In this paper data from 9 years of graduates from a northeastern liberal arts college are used to investigate the factors important in the decision to take a first STEM course, and conditional upon that the decision to take more courses within a STEM department. Evidence is also provided about the influences on major choice in STEM departments. Many of the factors highlighted in the literature to date are found to be important here. Pre-college preparation, here measured by SAT scores and AP credits, is consistently correlated with taking more STEM courses. I didn't find strong or consistent role model influences, peer influences, or course size influences on attrition. The major findings of this study point to the importance of grades and pre-collegiate preferences in STEM attrition rates. Absolute grades are one of the largest and most persistent factors in the attrition of undergraduates from STEM departments. There is also some evidence that relative grades are important in some STEM disciplines. The intended major is also a primary factor in the decision to pursue courses in a STEM department. An interesting finding is that the relative importance of grades and preferences differs somewhat by gender. Men appear to be more sensitive to grades than women, while preferences have a stronger influence on women than men. The results from this study suggest that to increase our output of STEM graduates we need to focus on high school preparation to change preferences for STEM disciplines. If grading distributions in STEM departments were brought more in line with non-STEM departments it would also have an important positive influence on the attrition rates that STEM departments experience.

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