The Journal of Higher Education

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/uhej20

Grade Expectations: The Role of First-Year Grades in Predicting the Pursuit of STEM Majors for First- and Continuing-Generation Students

Marissa E. Thompson

THE JOURNAL OF HIGHER EDUCATION
2021, VOL. 92, NO. 6, 961–985
https://doi.org/10.1080/00221546.2021.1907169

Routledge
Taylor & Francis Group

Check for updates

Grade Expectations: The Role of First-Year Grades in Predicting the Pursuit of STEM Majors for First- and Continuing-Generation Students

Marissa E. Thompson

Graduate School of Education, Stanford University, Stanford, California, USA

ABSTRACT

Earning poor grades in early science, technology, engineering, and mathematics (STEM) college courses decreases the likelihood that a student will major in STEM. However, grades in first-year STEM courses do not impact students evenly, making it hard to know if early "gatekeeping" courses selectively push some students out of STEM. This descriptive study examines the relationship between grades and STEM persistence for first- and continuing-generation students. Using transcript and survey data from three moderately-selective postsecondary institutions, I find that among students with high STEM GPAs, first-generation students are less likely than their continuing-generation peers to persist in STEM, net background preparation and characteristics. Moreover, first-year STEM grades alone account for a substantial portion of the differences in the likelihoods of studying STEM. While first-generation students are slightly less responsive to their early STEM grades than continuing-generation students, their comparatively lower early STEM grades are a significant driver of persistence differences.

ARTICLE HISTORY
Received 7 May 2020
Accepted 19 March 2021

KEYWORDS
First-generation college students; higher education; parental education; STEM

Introduction

Studies of students' first-year experiences in science, technology, engineering and mathematics (STEM) fields nearly always include a discussion of so-called "weed-out" or "gatekeeping" courses. While the exact nature of a weed-out course may vary institution by institution, they often encompass early first-year STEM courses that purportedly separate students with the skills or grit to succeed in STEM from those without, thus serving a gatekeeping function. These difficult courses, which are required for STEM majors, are often cited as a prime reason for leaving STEM, not only because many students fail these courses, but also because the competitive environment may feel unwelcoming (Gasiewski et al., 2012; Kokkelenberg & Sinha, 2010; Seymour & Hewitt, 1997). Early postsecondary decisions and experiences play a disproportionately large role in structuring later experiences, with introductory courses in a student's freshman year often heavily influencing major choice (Chambliss & Takacs, 2014). For example, an amazing experience in an

CONTACT Marissa E. Thompson marissathompson@stanford.edu

introductory chemistry course might persuade an aspiring business student to consider a different major than he or she had previously thought. In contrast, a terrible experience in an introductory biology course might turn a would-be doctor away from medicine and toward other fields.

However, while these courses may be designed to selectively weed-out students who do poorly in the course and therefore perhaps cannot handle the rigor of a STEM major, experiences in these courses do not impact students evenly across demographic groups. Grades in these courses can differ systematically across demographic groups (Eddy et al., 2014; Ma & Liu, 2017), and students' responses to their grades also vary across a number of factors. Indeed, studies have indicated that women are more sensitive to low first-year grades in STEM and economics courses, while men who receive low grades are only slightly less likely than men with A's to continue on to major in these fields (Goldin, 2015; Ost, 2010; Rask & Tiefenthaler, 2008; Sanabria & Penner, 2017). Thus, when considering the impact of introductory courses, one must question who, exactly, is being weeded out.

Importantly, scholarly work has established that patterns of students' majors vary along several dimensions, including gender, race, and socioeconomic background (Chang et al., 2014; Goyette & Mullen, 2007; Ma, 2009; Witherspoon et al., 2019; Zafar, 2013). As majors carry different expected earnings in an individual's lifetime, systematic differences across demographic groups creates stratification even among students attending the same institutions. This study highlights the importance of grades, which are both one of the earliest forms of feedback that students receive in college as well as an academic obstacle for many students. Specifically, I examine the relationship between students' first-year grades and their likelihoods of pursuing and persisting in STEM fields, with an emphasis on understanding the experiences of first-generation college students.

As first-generation students, who do not have a parent with a four-year college degree, make up an increasingly large proportion of college students, scholars and policymakers have turned their attention toward better understanding their college experiences. Compared to their continuing-generation peers (those who have at least one parent with a four-year college degree), first-generation college students are more likely to come from low-income households and are more likely to experience social, economic, and academic obstacles while pursuing postsecondary degrees (Collier & Morgan, 2008; Harackiewicz et al., 2015; Jack, 2014, 2016; Pascarella et al., 2004; Redford & Hoyer, 2017; Sirin, 2005; Stephens et al., 2012). These challenges can impact major choice and opportunity (Chen & Soldner, 2013; Goyette & Mullen, 2007; Ma, 2009), resulting in inequality in students' fields of study. By better understanding the factors that can affect major choice and retention, administrators and policymakers can be better positioned to enact policies that might improve persistence and promote equity.

This study examines the relationship between first-year grades in STEM and persistence for both first- and continuing-generation college students. While prior literature has focused on how grades and different levels of grade sensitivity impact the gender and racial gap in STEM, comparatively less is known about the relationship between grades, STEM persistence, and parental education. Drawing on Social Cognitive Career Theory (Lent et al., 1994, 1999), which emphasizes the importance of academic performance and self-conceptions in shaping individuals' likelihoods of persistence in a field, I address the following research questions: How are grades in entry-level STEM courses associated with persistence in STEM for first- and continuing-generation students? Are there differences in sensitivity to first-year STEM grades by parental education? To what extent do these relationships explain differences in STEM persistence by parental education?

To answer these questions, I leverage data from the Pathways through College Research Network (PCRN) study, which includes extensive survey and administrative data from students at three moderately-selective postsecondary institutions in geographically distinct regions of the United States. Using the PCRN data, I assess the relationship between grades in first-year STEM courses and STEM persistence for both first- and continuing-generation students, as well as how responsiveness to early earned grades differs for these groups. Moreover, because PCRN includes data on students' preferences, background high school preparations, and grades outside of STEM courses, I am also able to quantify the extent to which grades are associated with gaps in STEM by parental education in comparison to other potential factors. In doing so, I aim to better understand the factors influencing student persistence in STEM fields and the experiences of first-generation students.

Background

First- and continuing-generation students in STEM

Several economic, social, and academic barriers contribute to differences in the college experiences of first- and continuing-generation college students. Students' social, financial, and cultural capital influences their abilities to navigate the complexities of their college experiences, which advantages continuing-generation students (Armstrong & Hamilton, 2013; Collier & Morgan, 2008; Jack, 2016). First-generation college students are more likely to come from low-income households with fewer economic resources than continuing-generation students (Pascarella et al., 2004; Redford & Hoyer, 2017; Stephens et al., 2012). First-generation students also tend to have had lower high school grades and had fewer pre-college educational opportunities than their continuing-generation peers (Redford & Hoyer, 2017;

Stephens et al., 2012), which can impact college experiences and likelihoods of persisting. Furthermore, students from low-income or working-class backgrounds are more likely to rely more heavily on financial aid or work-study to finance their educational pursuits (Warburton et al., 2001). This limits not only time spent on academic pursuits, but also access to certain social groups and extracurricular activities, particularly for STEM degrees that may require more than four years to complete. Finally, because navigating the structure of universities at times requires specific knowledge, opportunities for academic success can be limited by obstacles that require cultural and social capital, such as understanding professors' expectations (Collier & Morgan, 2008; Jack, 2016), meeting with academic advisors (Swecker et al., 2013), and the strategic choice of courses and major (Goyette & Mullen, 2007; Stephens et al., 2014). These early choices are particularly crucial in determining students' later collegiate experiences.

In STEM fields, prior studies have found that first-generation students leave at higher rates than their continuing-generation peers (Chen & Soldner, 2013). There are several mechanisms that may be related to this phenomenon. First, different levels of background preparation has been linked to differential likelihoods of pursuing and persisting in STEM, with students who are less academically prepared or who attended underserved high schools facing more academic challenges in college than their peers (Griffith, 2010). Furthermore, achievement gaps within early gateway courses may be an underlying cause of differential attrition in STEM, as students with lower college grades are more likely to leave STEM fields than their peers (Chen & Soldner, 2013). If first-generation students are systematically earning lower grades in first-year STEM courses, this can affect differences in the likelihood of choosing a STEM major and persisting in that major. Moreover, STEM degrees typically take longer to complete than non-STEM degrees, making the field less accessible for those relying on financial aid to fund their studies, particularly if the student in question will need more than four years to complete the program (Fenske et al., 2000). Finally, given the "pipeline" nature of STEM curricula, including large numbers of prerequisites, students often cannot progress in a sequence of courses without first passing these gatekeeping courses (Gayles & Ampaw, 2016). However, STEM degrees are some of the most lucrative bachelor's degrees, with high average early earnings and high wage growth over one's lifetime (Carnevale et al., 2015). Thus, inequality in access to STEM has implications not only within the college context but also for social mobility.

Importantly, students from first-generation or low-income backgrounds do not have homogenous experiences in the education system or in college more specifically (Jack, 2014, 2016). On the whole, however, the challenges facing these students creates an environment in which continuing-generation and middle/high-income students often have an advantage in the navigation of higher education and in the important decision of choosing a major.

Grades, major declaration, and persistence

Students' first year academic experiences, including grades and experiences in first-year "gatekeeping" courses, are important predictors of major choice and later academic success (Bar et al., 2009; Chang et al., 2014; Dika & D'Amico, 2016; Sabot & Wakeman-Linn, 1991; Seymour & Hewitt, 1997). Grades provide a signal of student skill to employers, postsecondary institutions, and others (Mullen et al., 2003; Pattison et al., 2013; Quadlin, 2018), with higher postsecondary grades linked to higher wages in employment (Jones & Jackson, 2006). Students with higher first-year GPAs are more likely to major in STEM, while students with low first-year GPAs are often dissuaded from studying STEM subjects in favor of other fields (Seymour & Hewitt, 1997). As noted by one STEM major interviewed by Seymour and Hewitt, "a hell of a lot of self-esteem is attached to those grades" (Seymour & Hewitt, 1997, p. 39).

Average grades in STEM courses are typically much lower than for other fields, which may incentivize students to leave STEM majors in favor of majors where they feel they might have a higher chance of receiving a better grade, or that they sense is a better fit with their perceived academic capabilities. Lower numbers of students studying STEM subjects as compared to non-STEM subjects is primarily due to students' performance in early college math and science classes, rather than students entering college with low levels of interest in these fields (Stinebrickner & Stinebrickner, 2011). When students learn that their academic performance in math or science courses will be lower than expected, students update their beliefs accordingly. Students who substantially underperform relative to their expectations are more likely to choose a non-math or science major, an indication that students are "pushed out" of STEM majors rather than being "pulled out" by more appealing non-STEM fields (Stinebrickner & Stinebrickner, 2011). For low-income students in particular, perceptions of grades and other academic feedback have a large influence on decision-making about major choice (Stinebrickner & Stinebrickner, 2012). In fact, Stinebrickner and Stinebrickner (2012) estimated that 40% fewer low-income students would have dropped out after their first year of college if they not been provided information about their grades and academic performance. Similarly, high early grades in STEM have been shown to increase persistence in STEM for first-generation students (Dika & D'Amico, 2016), as well as for students overall (Whalen & Shelley, 2010).

In this analysis, I define *grade sensitivity* as a student's responsiveness to grades earned, such as the impact that receiving a high or low grade in an early course might have on a student's persistence in the subject (Rask & Tiefenthaler, 2008). This can be measured both by persistence to a subsequent course in the field or selection of the discipline as a major. Here, I focus on the selection of and persistence through a major, which is often the culmination of a sequence of many courses in the field. Most, though not all, of prior work on responsiveness to grades has focused on gender. The bulk of studies on grade sensitivity patterns by gender have focused on two areas where women are underrepresented: economics (Goldin, 2015; Main & Ost, 2014; Owen, 2010; Rask & Tiefenthaler, 2008) and STEM fields (Ost, 2010; Sanabria & Penner, 2017). These studies consistently find gender differences in how students respond to their grades, with women disproportionately leaving economics or STEM fields if they receive low grades in (or fail) key introductory courses. These patterns were not observed when considering underrepresented minority (URM) students in STEM fields (Ost, 2010), though far fewer studies have been devoted toward understanding grade sensitivity by race than by gender. However, sensitivity to grades by parental education remains understudied.

Conceptual framework

Theoretically, I draw primarily from Social Cognitive Career Theory (SCCT), which has been used to help explain student persistence in a variety of contexts, including in STEM fields (Lent et al., 1994, 1999). SCCT builds on theories of self-efficacy (Bandura, 1986) to link students' persistence in a career path with their expectations and self-efficacy. For example, success in a course or field tends to raise a student's self-efficacy, increasing the likelihood that that student will remain on that career path. In contrast, poor experiences, including bad grades, lowers a student's self-efficacy and sense of belonging in that field and lowers the likelihood that he or she will persist. Thus, the study of grades, and early grades in particular, are of key importance to understanding student persistence.

Previous studies on the effect of grades on persistence have yielded different results by race and gender, making it unclear if we might expect grade sensitivity patterns to differ by parental education. Both women and URM students are underrepresented in STEM disciplines. And yet, while multiple studies have indicated that women are more sensitive to their first-year grades than men, evidence thus far has shown that URM students are not differentially sensitive to early earned grades compared to white and Asian students. Given existing studies on the mechanisms driving gaps in STEM by race and gender, it is perhaps not surprising that that there are different patterns for these groups. For example, in a study of how high school STEM course-taking patterns is associated with STEM degree attainment in college, Tyson et al. (2007) found that, though there are persistence gaps in STEM baccalaureate attainment by both gender and race, the mechanisms underlying each of the gaps differed. For women, gaps appeared to be driven by lower levels of initial STEM pursuit upon entering college, even among those who had taken the highest-level math and science courses in high school. Lower levels of math- and science-related self-efficacy have been tightly liked to gender differences in likelihoods of entering STEM fields (Cech, 2015; Correll, 2004), consistent with SCCT. In contrast, Tyson et al. (2007) found no differences in STEM degree pursuit between White students and Black or Hispanic students who had completed the highest-level of math and science courses. However, because on average Black and Hispanic students completed much lower levels of STEM courses in high school, gaps persisted into their college years (Tyson et al., 2007).

Given that the relationship between parental education and grade sensitivity is less well understood than factors such as race and gender, it is possible that factors such as lower levels of self-efficacy might lead first-generation students to have higher levels of sensitivity to their grades, similar to women in the sciences. First-generation students tend to enter college with lower levels of self-efficacy (Ramos-Sánchez & Nichols, 2007), and also tend to perceive more barriers to their college success than their continuing-generation peers (Gibbons & Borders, 2010). Furthermore, they also have a higher fear of failure more generally (Bui, 2002), and lower academic expectations (Gibbons & Borders, 2010). This might suggest that first-generation students might be more sensitive to their early earned grades than continuing-generation students. However, it is possible that gaps in STEM degree attainment by parental education follow patterns more similar to those for URM students, with potential differences driven primarily by different levels of prior preparation or early performance. As previously noted, first-generation students tend to have lower levels of prior preparation than their continuing-generation peers (Redford & Hoyer, 2017; Stephens et al., 2012), which could also lead to lower grades. On the other hand, because continuing-generation have higher expectations of their grades on average, and have more access to information from parents and family about the implications of their grades, it could also be the case that continuing-generation students are more sensitive to early grade information, particularly if they fail to meet their own expectations. Thus, the expected direction of any differences in grade sensitivity levels are not immediately clear.

Though studies on grade sensitivity have indicated a link between gender and grade responsiveness, and a lack of observed differences in this responsiveness by race, these studies have yet to establish how other demographic characteristics might be related to a students' grades and the persistence. Missing from the existing literature are studies on how grades impact students by parental education, and which other mechanisms might interact with students' backgrounds to affect their persistence in STEM. This is of key importance given the widespread use of "gatekeeping" early courses in STEM and related disciplines, which could potentially disproportionately discourage students from pursuing these fields (Gasiewski et al., 2012).

Data

I leverage data from the Wisconsin Center for Education Research (WCER) Pathways through College Research Network (PCRN) study (n = 2720),[1] which includes five waves of survey data collected from students at three large moderately-selective universities located in geographically distinct areas of the United States (Grodsky & Muller, 2018). To protect the privacy of the institutions and students involved in the study, these institutions are not named. One of the three institutions is private, while two are public. They are located in the Midwestern, Western, and Eastern regions of the United States, respectively. Given that students were selected using a probability sample of first-year students, the PCRN data is a representative of the population of first-year students at these institutions. Institutions were also selected because of their emphasis on STEM majors, including initiatives to improve STEM persistence and retention, making this a particularly well-suited dataset for answering questions related to entrance and persistence in STEM.

Administrative data on students' demographic backgrounds were also included in the dataset, along with full academic transcripts and other administrative information. Survey data was collected from fall 2014 through spring 2016 and included questions on students' previous experiences before enrolling in college, current experiences in their school and major, as well as expectations and aspirations for the future, with students repeatedly sampled in each wave throughout the study. Survey sampling occurred once each semester, though in a small number of cases students did not participate in all surveys and are missing from waves. The analytic sample for this study included 803 first- (n = 352) and continuing-generation (n = 451) students who entered college open to studying a STEM major (which I define as either entering without a stated major interest or with a specific interest in STEM) and who had provided information on their parents' educational attainments. All analyses are limited to this sample with complete data on demographic background, outcomes, and all covariates.

The students in these institutions do not constitute a representative sample of college students nationally, and the results of this study cannot be generalized across all institution types. However, because my focus is on parental education, particularly the experiences of first-generation students, I opted to use data from colleges that are more accessible to first-generation students, as indicated by the high percentages of the student population that are first-generation. Results from this study can provide information that can improve understanding of the relationship between parental education and grade sensitivity for these samples.

Measures

Students provided their initial and final major in survey questions. Importantly, because not all of the students had graduated from college at the time of the study, their final observed major is not necessarily an indication that they had in fact graduated from that field in the case of students who may have changed majors after the conclusion of the study. STEM and non-STEM subjects were coded using the U.S. Department of Education CIPS codes.[2]

Students' STEM GPAs were coded as the cumulative weighted GPA of all courses in a STEM subject in a student's first year. Some courses at the universities could be retaken for credit (thereby expunging the first iteration of the course from the student's GPA). However, because the primary variable in this study is students' initial STEM GPAs, not retaken courses, I opted to use the first grade reported for retaken courses. However, results are consistent when including retaken courses in GPAs, and the differences between standard GPAs and initial GPAs were not significantly different by parental education. Non-STEM GPAs were coded as the cumulative weighted GPA of all non-STEM courses in a student's first year.

Students' parental education and first-generation status was determined using students' self-reported parental education. I define first-generation college students as those for whom neither parent has a four-year college degree. If students' highest parental education level was an associate's degree, or if their parent had attended (but not graduated from) a four-year degree program, they were coded as first-generation college students. In the analytic sample, 236 students reported that neither of their parents had any type of higher education degree, while 116 reported that one parent had at least an associate's (but not a bachelor's) degree. Moreover, 232 students reported that the highest degree earned from one of their parents was a bachelor's degree, and another 219 reported that one or both of their parents had a professional or graduate degree. In addition to survey questions on parents' educations, each of the three institutions provided a flag to indicate which students were considered first-generation based on administrative reports. However, the institutional definition of first-generation was not available, and given that institutions sometimes use different definitions of first-generation status, which can affect outcomes (Toutkoushian et al., 2018), I opted to use students' self-reports to ensure that a consistent definition of first-generation status was maintained across the three institutions.

In addition to students' GPAs and first-generation status, I also leveraged administrative and survey data on students' demographic background (including race and gender). Unfortunately, only one of the three institutions provided administrative data on students' family income or federal Pell Grant eligibility, thus it was not possible to use these measures in the models due to sample size restrictions. Students were also asked about their prior high school preparation, including their cumulative GPA in math courses in high school and their exposure to calculus in high school (coded as a binary indicator variable). I also used survey measures collected in the first two rounds of the survey indicating students' perceived math and science identities and their reported reasons for choosing their intended major or field. For math and science identities, students were asked if they see themselves as math or science people, as well as if others would identify them as such using a 5-point Likert scale. Similarly, students were asked to use a 5-point Likert scale to rate their reasons for choosing their major, which included engaging entry level classes, engaging advanced classes, keeping career options open for now, the amount of money they will earn right after college, the amount of money they will earn over the course of their career, and helping other people in their job or career. These measures give insight into students' mind-sets around their majors and their math or science self-perceptions during their early time in college.

Method

Analytic strategy

I present analyses in two parts. First, to examine the relationship between grades, parental education, and persistence in STEM, I use logistic regression. These models include all covariates as well as interaction terms to determine if the relationship between earned grades and persistence differs by parental education, controlling for all other factors. Next, I use Fairlie decomposition models, which use logistic regression and counterfactual substitution of coefficient values to determine how factors are associated with gaps in outcomes by parental education. This allows me to determine the percent of the observed gap that is accounted for by differences in *covariates* by parental education, as compared to differences in *coefficients* across parental education.

Logistic regression models

I operationalize students' responsiveness to their grades as the relationship between students' first-year STEM GPAs and their likelihood of pursuing and persisting in the field until the final round of the study. Students who are highly responsive to their grades are more (or less) likely to persist in a given field depending on the grades they have earned, compared to their peers.

Using logistic regression, I model the relationship between students' earned grades, their parental education, and their persistence in a field. Models control for gender, race/ethnicity, high school math experience/exposure, and survey questions on a variety of measures, including science identity and reasons for choosing their major. Furthermore, because I am primarily interested in differences by parental education, I use interaction coefficients to determine how GPA variables depend on a student's first-generation status. However, given that coefficients on non-linear models cannot be interpreted directly when considering the significance of particular relationships (Mize, 2019), I also present average marginal effects in tables and figures. Finally, I use doubly robust inverse probability weighting (IPW) to correct for any differences in the likelihood of attrition from the PCRN study entirely. Both weighted and unweighted results are displayed in logistic regression tables.

Given that many eventual STEM students begin their studies as undeclared or undecided (Gayles & Ampaw, 2016), models were only estimated among students who entered their institution with a stated interest in studying STEM or who did not list a specific major interest. This ensured that students who were never interested in studying STEM were not included analyses, while still considering undecided students who may become eventual STEM students. To control for any variation between students specifically interested in a STEM field, I include indicator variables for if a student noted a specific interested in either the life sciences or the physical sciences. Furthermore, models were estimated using an institution-level fixed effect to control for any unobserved factors that vary at the institution level.

I estimate the following models:

$$P(R5\ Major\ STEM = 1) = \frac{e^{\beta' X}}{1 + e^{\beta' X}} \tag{1}$$

where

$$\begin{aligned} \beta\prime X_{ij} = \alpha + \beta_1 FirstGen_{ij} + \beta_2 STEMGPA_{ij} \\ + \beta_3 FirstGen_{ij} * STEMGPA_{ij} \\ + \beta_4 NonSTEMGPA_{ij} + \beta_5 FirstGen_{ij} \\ * NonSTEMGPA_{ij} + \beta_6 W_{ij} + \lambda_j + \varepsilon_{ij} \end{aligned}$$

R5 Major STEM is a dichotomous variable indicating if student i at institution j reports majoring in STEM during the final round of the survey. $FirstGen_{ij}$ is an indicator variable for whether student i at institution j is a first-generation college student. $STEMGPA_{ij}$ is the cumulative GPA in STEM courses for student i at institution j, while$NonSTEMGPA_{ij}$ is the cumulative first year GPA outside of STEM fields for student i at institution j, and λ_j is an institution-level fixed effect. All GPA variables are on a standard 4.0 grading scale. W_{ij} is a vector of student-level covariates, including high school math background (using a dichotomous variable for exposure to pre-calculus in high school and the student's cumulative high school math GPA), percent of first-year credits that were in STEM courses, number of withdrawn courses in the first year, self-reported perceived science identity, initial STEM interests, self-reported reasons for choosing major, race/ethnicity, and gender. These covariates cover students' prior preparation from high school, with a particular focus on their math background, which has been shown to influence choice of major and responsiveness to grades in other contexts.

As previously noted, I also estimate average marginal effects (AMEs) to better understand the key interaction of interest between students' first-year STEM GPA and their first-generation status.

Fairlie decomposition models

Next, I quantify the relative contribution of each of the model covariates to explaining the difference in STEM major persistence between first- and continuing-generation students. To do so, I use Fairlie decomposition models (Fairlie, 2005) to predict likelihoods of STEM major declaration. This can give an indication of the explanatory power of STEM and non-STEM grades in explaining differences in the predicted probabilities of majoring in STEM by parental education, compared to other factors such as prior preparation, demographic background, or survey items such as perceived math/science identity. The primary aim of the decomposition models is to determine the relative importance of students' first year grades in explaining their likelihoods of persisting in STEM, helping to better understand the impact that these experiences might have on the gap in STEM-major declaration by parental education.

I include tables with coefficients from both a pooled model and a continuing-generation student model to identify how much of the gap might be explained by each covariate. Coefficients from the pooled model indicate the average contribution of each covariate across parental education, while the covariates for the continuing-generation model show the average contribution of each covariate under a hypothetical situtation where first-generation students have the same distribution of the covariate that continuing-generation students have. Thus, this allows for a more in-depth investigation of whether observed gaps are primarily due to group differences in the covariates or group differences in the coefficients associated with each covariate. For consistency, the same covariates used in the logistic regression model are used in the decomposition models.

Results

Descriptive statistics

I first display descriptive statistics of the measures used in all models for this study (see Table 1, below). As expected, students' STEM GPAs are

Table 1. Descriptive statistics of analytic sample.

	Continuing-Generation		First-Generation		Difference			
	Mean	*SD*	Mean	*SD*	Mean Diff.	*SE*	Min	Max
1st Year STEM GPA	2.71	0.97	2.56	0.89	0.15***	0.07	0	4
1st Year Non-STEM GPA	3.08	0.83	2.80	0.89	0.27***	0.06	0	4
% of first year courses in STEM	0.60	0.19	0.58	0.19	0.03	0.01	0.07	0.91
Withdrawn Courses	0.23	0.74	0.13	0.47	0.09	0.05	0	6
HS Calculus Exposure	0.66	0.47	0.54	0.50	0.13***	0.03	0	1
HS Math Grade	3.29	0.74	3.25	0.76	0.03	0.05	0	4.33
Science Identity (Self-Identify)	3.85	0.97	3.77	1.00	0.08	0.07	1	5
Science Identity (Others Identify)	3.69	0.96	3.62	0.97	0.07*	0.07	1	5
Math Identity (Self-Identify)	3.40	1.22	3.35	1.23	0.05	0.09	1	5
Math Identity (Others Identify)	3.49	1.07	3.32	1.12	0.17	0.08	1	5
Choosing Major: Entry-level Courses	3.41	1.03	3.54	1.01	-0.12*	0.07	1	5
Choosing Major: Advanced Courses	3.96	0.89	3.84	0.97	0.12*	0.07	1	5
Choosing Major: Open Career Options	3.88	0.92	3.96	0.87	-0.08*	0.06	1	5
Choosing Major: Money After College	3.63	0.96	3.59	0.97	0.03	0.07	1	5
Choosing Major: Money in Career	3.94	0.96	3.89	0.96	0.05	0.07	1	5
Choosing Major: Helping Others	3.89	1.01	4.03	0.94	-0.14*	0.07	1	5
Initial STEM Interests (Life Sciences)	0.29	0.45	0.32	0.47	-0.03	0.03	0	1
Initial STEM Interests (Physical Sciences)	0.05	0.22	0.05	0.21	0.00	0.02	0	1
Observations	451		352		803			

Note: * p<0.05, ** p<0.01, *** p<0.001. Sample limited to analytic sample of undeclared students and students interested in STEM upon entry.

markedly lower than their non-STEM GPAs, a pattern that is observed among both continuing- and first-generation college students. This is consistent with prior literature on STEM grading distributions. Two-sample t-tests indicate that average grades for first-generation students are significantly lower than their continuing-generation peers in both STEM and non-STEM courses. Average differences in GPA by parental education is equal to approximately 0.15 grade-points (on a 4.0 scale) in all subjects, or about half of a grade-level on a standard grading scale (where a standard grade-level, such as the difference between an A- and a B+, is roughly 0.33 grade-points). Among students in the analytic sample, first- and continuing-generation students enter schools with statistically similar levels of interest in pursuing a major in STEM. First-generation students are less likely than their continuing-generation peers to report exposure to calculus in their high school math curriculum and are more likely to say that others view them as "science people," though the other measures of math and science identity are statistically similar. Finally, first-generation students report that engaging entry-level courses, keeping career options open, and a career that might help others are significantly more important to them than their continuing-generation peers, while continuing-generation students are more likely to report that advanced courses are important considerations in their choice of a major. Figure 1 displays the distributions of students' first year STEM GPAs, by parental education, along with percentiles and mean GPAs.

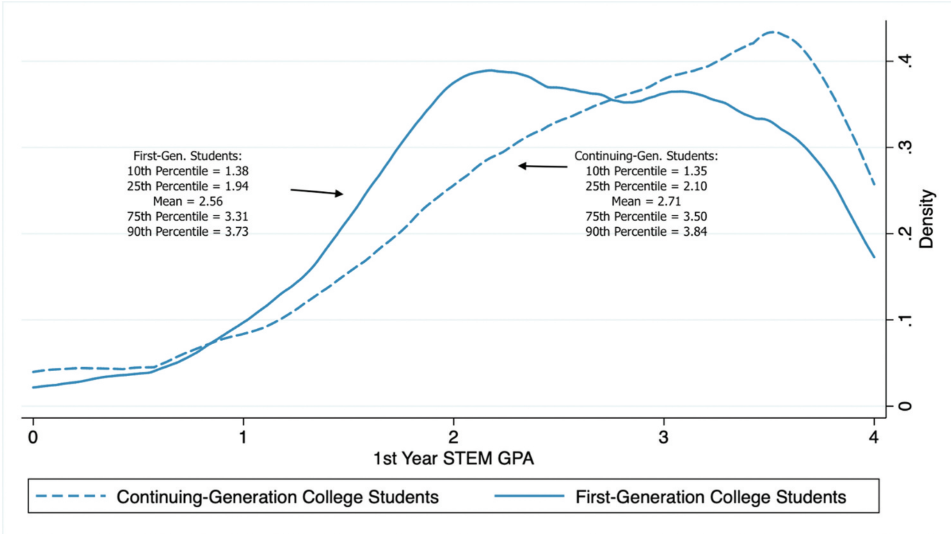

Figure 1. Distribution of 1st year STEM GPAs, by students' parental educations.

Sensitivity to grades

Table 2 (below) presents logistic-regression results (both weighted and unweighted), with coefficients in log-odds. However, it is important to note that log-odds are not directly interpretable, and *p*-values from interaction effects predicting dichotomous outcome variables can be misleading without a more thorough investigation of average marginal effects (see Figure 2 and Table 3 for average marginal effects). Thus, in addition to the logistic regression models, I also present an investigation of both sides of the interaction effect, meaning both the marginal effect of first-generation status, as well as the marginal effect of changing first-year STEM GPAs.

Table 2. Logistic regression results predicting STEM major persistence.

	(1)	(2)	(3)	(4)
First-Generation	0.687***	0.633*	0.521**	0.465*
	(0.184)	(0.256)	(0.201)	(0.184)
1st Year STEM GPA	0.478	0.780	0.111	0.180
	(0.854)	(0.649)	(0.672)	(0.458)
First-Generation x 1st Year STEM GPA	−0.0679	−0.113	−0.0292	−0.0391
	(0.0751)	(0.0710)	(0.0302)	(0.0297)
1st Year Non-STEM GPA	0.372	0.450+	0.138	0.195
	(0.273)	(0.231)	(0.299)	(0.230)
First-Generation x 1st Year Non-STEM GPA	−0.198	−0.258	−0.0802	−0.0936
	(0.231)	(0.186)	(0.231)	(0.152)
Inverse Probability Weighted	No	No	Yes	Yes
Survey Covariates Included	No	Yes	No	Yes
Institution Fixed-Effect	Yes	Yes	Yes	Yes
Pseudo R-squared	0.211	0.249	0.111	0.139
Observations	803	803	803	803

Standard errors in parentheses. + $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

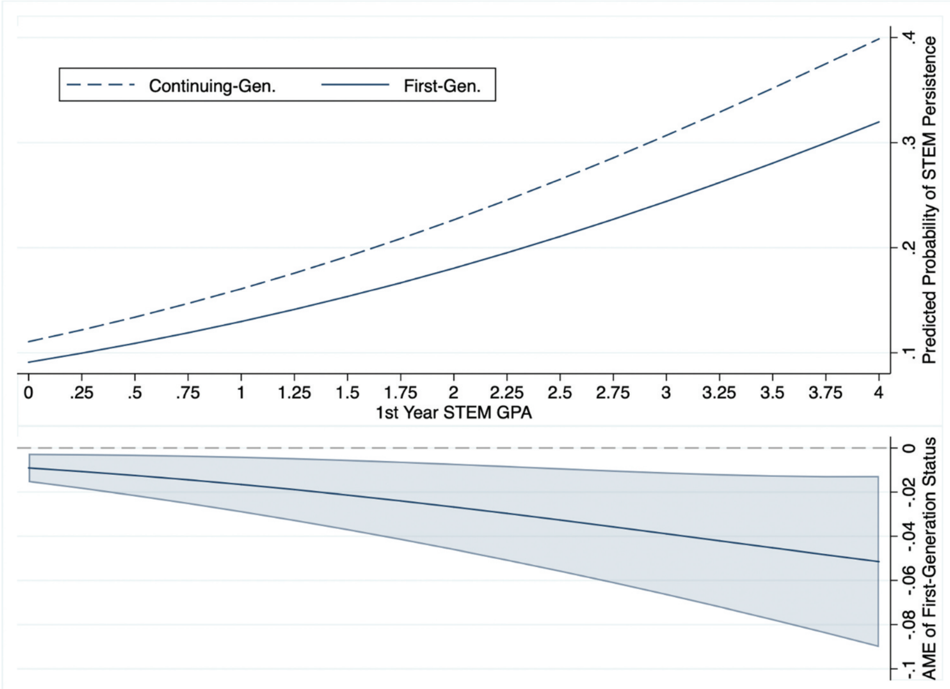

Figure 2. Predictive margins of students' STEM GPAs, by parental education. Negative AMEs in the second panel indicate that first-generation students are less likely to major in STEM at a given STEM GPA. Shaded region indicates 95% confidence intervals.

Table 3. Results for how STEM major persistence is associated with STEM GPA and first-generation status: tests of average marginal effects (AMEs) and second differences (n = 803).

Change in STEM GPA	*AME* continuing-gen.	*AME* first-gen.	Second Difference
+0.25 point on average	0.021**	0.016*	−0.004***
	(0.008)	(0.008)	(0.001)
+0.5 point on average	0.042**	0.034*	−0.009***
	(0.016)	(0.017)	(0.002)
1.5 → 2.0	0.035***	0.027*	−0.008**
	(0.010)	(0.011)	(0.002)
2.0 → 2.5	0.038**	0.030*	−0.008***
	(0.013)	(0.014)	(0.002)
2.5 → 3.0	0.042**	0.033*	−0.009***
	(0.016)	(0.017)	(0.002)
3.0 → 3.5	0.045**	0.036+	−0.008**
	(0.018)	(0.020)	(0.003)
3.5 → 4.0	0.047*	0.039+	−0.008**
	(0.020)	(0.022)	(0.003)

Standard errors in parentheses. + $p < .10$, * $p < .05$, ** $p < .01$, *** $p < .001$.

Figure 2 illustrates the average marginal effect (AME) of first-generation status by STEM GPA. Note that the term *effect* in *average marginal effect* is intended to be descriptive and does not indicate a causal relationship. Results in Figure 2 can be interpreted as the predicted probability of persistence in STEM at a given GPA level, holding all else constant. For clarity of interpretation, I also display the difference between first- and continuing-generation students with 95% confidence intervals. As can be seen in the figure, at every STEM GPA, continuing-generation students are much more likely to persist in STEM given the same grades and controlling for background characteristics. For students with approximately a 4.0 in their first-year STEM courses, continuing-generation students are approximately 8 percentage points more likely to major in STEM than their first-generation peers. The gap narrows between students with lower STEM GPAs. For example, the gap is approximately 7 percentage points among students earning a 3.5 GPA in their first-year STEM courses, 5 percentage points for students earning a 2.0 GPA, and 3 percentage points for students earning a 1.0 GPA. This indicates that, among students earning high grades in their introductory STEM courses, continuing-generation students are much more likely to eventually major in STEM than their first-generation peers. For comparison, the gap in STEM major declaration by parental education is about 7 percentage points on average.

Table 3 presents results for how STEM major persistence is associated with both STEM GPA and first-generation status, which were tested using AMEs and second differences. Results presented indicate how, holding all else constant, increases in students' STEM GPAs are associated with changing predicted probabilities of persisting in STEM separately by parental education, with second differences illustrating whether differences by parental education are significant. On average, a 0.5-point increase in STEM GPA (equivalent to slightly more than a grade-level), is associated with an increase in the predicted probability of persisting in STEM for both first- and continuing-generation students. However, the boost in the predicted probability of studying STEM associated with a 0.5-point increase is significantly higher for continuing-generation students than for first-generation students, which is also true for a 0.25-point increase on average. These values change depending on where in the grading distribution AMEs are tested. At high STEM GPAs, 0.5-point increases boost the likelihood of persisting in STEM by nearly 5 percentage points for continuing-generation students, while for first-generation students this value is about 4 percentage points. At lower STEM GPAs, continuing-generation students also appear more responsive to their grades, with an increase of 0.5 GPA-points associated with a higher increase in the likelihood of persisting in STEM for continuing-generation students compared to first-generation students. It should be noted, however, that students at these low GPAs have much lower rates of persisting in STEM overall.

Decomposition models

Finally, I examine the relative explanatory contribution of grades to the parental education gap in STEM major pursuit and persistence. Table 4 (below) disaggregates each of the covariates used in the logistic regression models, where the contribution of each covariate is net other measures used in the model. Model 1

Table 4. Fairlie decomposition analysis of factors explaining parental education differences in STEM major persistence.

	(1)		(2)	
	Continuing-Gen Coefficient Model		Pooled Coefficient Model	
% Continuing-Gen Majoring in STEM	0.30		0.30	
% First-Gen Majoring in STEM	0.23		0.23	
Gap in STEM Major	0.07		0.07	
Contribution to the gap due to differences in:				
1st Year STEM GPA	0.015+	20.8%	0.013*	18.6%
	(0.008)		(0.006)	
1st Year Non-STEM GPA	0.014	19.1%	0.010	14.1%
	(0.011)		(0.008)	
% of first-year courses in STEM	0.013*	17.3%	0.013**	17.9%
	(0.005)		(0.004)	
Withdrawn Courses	-0.001	-1.2%	-0.001	-1.4%
	(0.002)		(0.002)	
Initial STEM Interest Measures	0.0004	0.5%	0.001	0.7%
	(0.003)		(0.003)	
High School Preparation Measures	0.001	1.7%	0.007	10.2%
	(0.008)		(0.005)	
All Math/Science Identity Measures	-0.005	-6.9%	-0.001	-2.0%
	(0.007)		(0.005)	
All Reasons for Choosing Major Measures	-0.002	-2.6%	-0.002	-3.2%
	(0.008)		(0.006)	
Demographic Background	-0.008	-11.5%	-0.008	-11.4%
	(0.009)		(0.006)	
All Variables (Total Percent of Gap Explained)	0.027	37.4%	0.031	43.6%
Observations	803		803	

Standard errors in parentheses. +p<0.10 * p<0.05 ** p<0.01 *** p<0.001. Models were estimated only among students who entered college either undecided or with intentions to study a STEM major. Decomposition coefficients are from both a continuing-generation coefficient model and pooled model over 1000 randomly selected subsamples.

in the table shows the relative explanatory contribution of the covariate if first-generation college students had the same distribution of each covariate as continuing-generation students, while Model 2 illustrates the relative explanatory contribution if covariate distributions were equalized by parental education. As can be seen in the table, the overall gap in STEM major declaration between first- and continuing-generation students is about 7 percentage points. Using the covariates from the logistic regression models, I explain about 40% of the gap, whereas a substantial portion of the gap remains unexplained by the factors used in this analysis. However, students' first-year STEM GPAs alone account for approximately 19% of the total gap in STEM major persistence between first- and continuing-generation students. Students' non-STEM GPAs were not significant predictors of the gap and did not appear to pull students out of STEM fields. In addition to students' first-year STEM GPAs, the percent of first-year courses that are STEM courses was also a significant predictor of the gap in STEM major declaration by parental education (18%), while high school preparation, math/science identity, initial STEM interests, and reasons for choosing a major were not significant predictors of the gap. These models indicate that, if one were to increase first-generation students' first-year STEM grades and the percent of first-year courses that they enroll in in STEM, we might expect to see much smaller differences in the likelihood of majoring in STEM when compared to continuing-generation students.

Discussion and conclusions

This study presents evidence on the impact of early STEM grades on persistence in STEM by students' parental education levels. The patterns described in this analysis differ from those observed by both gender and race in previous research. Specifically, I find that first-year STEM grades are tightly linked to gaps in STEM persistence by parental education. There are two main takeaways from this study. First, gaps in persistence in STEM are explained in part by first-generation students earning lower grades in their early STEM courses rather than due to differences in grade sensitivities. In fact, continuing-generation students are slightly more responsive to their grades. Second, even among students earning high grades in first-year STEM courses and with similar levels of background preparation, first-generation students are less likely to persist in STEM than their continuing-generation peers, suggesting that other interventions besides increasing average grades might be necessary to promote more even retention in STEM.

STEM grades alone account for approximately 19% of the parental education gap in STEM major declaration, which is a sizable portion in comparison to other potential factors. The relationship between grades and persistence is due mostly to lower grades for first-generations students, not due to heightened sensitivity to grades. In fact, continuing-generation students are actually more sensitive to low grades, and more sensitive to grades on average than first-generation students. However, STEM persistence levels among high STEM GPA earners are consistently lower for first-generation students compared to continuing-generation students with similar grades and background characteristics. This pattern does not appear to be driven by differential interests in the sciences upon entering college. In fact, among students in the sample, first- and continuing-generation students enter with similar levels of STEM interest. By including both students with a specific interest in STEM as well as those who did not list a specific interest in their first semester, I am able to examine generally the factors that push and pull students out of STEM. This effect also does not appear to be driven by students earning higher grades outside of STEM and being "pulled out" of a STEM pathway. Students' early STEM grades exhibit a much larger influence on their likelihood of majoring in STEM, while non-STEM grades were not significantly related to either students' likelihoods of majoring in STEM or to differences in STEM major declaration by parental education.

All students are sensitive to their grades, with increases in students' STEM GPAs associated with statistically significant boosts in their likelihoods of majoring in STEM. The marginal effect of decreasing from a high STEM GPA to a more modest or low STEM GPA is large and significant. While these data do not allow a more in-depth probing of students' thought processes as they consider their early grades and majors, this indicates that first-year grades are of prime importance to students as they make decisions about their pathways. For STEM departments, this can present a problem with persistence because STEM grades are much lower than grades in non-STEM departments, and low grades are significantly associated with decreased likelihood of studying a STEM subject.

The mechanisms underlying the patterns described in this study are unclear. All students are sensitive to their grades, which aligns with prior studies on how higher grades in STEM tend to increase a student's persistence in STEM fields (Ost, 2010; Rask, 2010; Whalen & Shelley, 2010). While these data do not allow for a direct test of the effect of grades on self-efficacy and self-confidence, these results are consistent with SCCT (Lent et al., 1994, 1999), where a student's academic performance is tightly tied to his or her self-efficacy and likelihood of persisting. Overall, continuing-generation students are slightly more sensitive to their grades. This could be due to differences in academic expectations, or due to differences in cultural and social capital associated with having a parent who attended college. For example, if continuing-generation students have higher expectations for their GPAs, and if these expectations are not met in terms of their earned grades, a lower grade might be more discouraging for continuing-generation students than for their first-generation peers.

Even when controlling for background characteristics, first-generation students in the sample tend to earn lower grades in their first year STEM courses. This is a primary source of the parental-education gap in STEM persistence, leading first-generation students to disproportionately leave STEM majors. The comparatively lower grades earned by first-generation students could be due to a number of factors associated with social and cultural capital that are outside of the scope of the available data, such as experiences with first-year courses and assessments, lower levels familiarity with faculty expectations (Collier & Morgan, 2008; Jack, 2016), higher fear of failure (Bui, 2002), differences in academic engagement (Gasiewski et al., 2012), or social experiences and perception of fit (Dika & D'Amico, 2016). Even for students with high STEM grades, navigating college and the expectations of a STEM major may prove less challenging for continuing-generation students, which could lead high-achieving first-generation students to seek out other fields. Because it is not clear whether student decisions or other university influences are the primary motivation behind the influence of grades on students' persistence, universities might also consider how advising and other institutional-level systems could, perhaps unwittingly, be promoting inequalities in STEM pathways. This could be, in part, due to the rigid structure of STEM curricula, where one must first pass several first-year introductory courses in order to progress to more advanced courses. Future work should investigate these underlying mechanisms in order to identify junctures for intervention, particularly with regard to university policy and grading practices (for example, moving to a pass/fail system for introductory courses). Universities might also consider promoting practices that increase students' likelihood of having important academic experiences and lead to higher likelihoods of retention (Chang et al., 2014).

There are several limitations to this study that provide opportunities for future work. First, the sample does not constitute a nationally representative group of students. Thus, findings cannot be generalized to the college-going population at large. However, because the institutions in the sample serve high proportions of first-generation students, inequity at these types of schools is of special concern to policymakers interested in increasing persistence in STEM for underrepresented groups. Second, administrative data only allows for the observation of changing majors in an official capacity, while any internal decision-making is unobserved. This is likely of particular importance for students who enter without a stated interest in any given major. While I include these students in analyses and control for initial STEM interests, future work might examine how early STEM interests (or lack thereof) are associated with sensitivity to grades. Future study might also incorporate a qualitative component to better understand students' conceptions of their grades and what they mean for their futures. Finally, this study is descriptive in nature and therefore cannot be used to establish a causal link between grades and persistence.

There are several important implications stemming from this study. First-generation students earning high grades are significantly less likely than their continuing-generation peers to persist in STEM fields. Furthermore, though continuing-generation students are more sensitive to their grades overall, grades have a large impact on the parental-education gap because first-generation students tend to earn lower grades on average than continuing-generation students. Finally, grades, paired with the percent of first-year courses in STEM that students take, explain a large and significant portion of the gap in STEM major declaration by parental education. Thus, policymakers and university administrators should consider the impact of grading policies around introductory STEM courses and any unintended consequences. While grades matter for all students, higher grades in introductory courses increase the likelihood that a student will stay on a STEM pathway. When students' persistence likelihoods are tightly tied to the grades they earn, but students do not have equal likelihoods of earning high grades or similar responses to the grades they do earn, gaps emerge even among students with similar background preparation and interest levels in STEM. Policies aimed at increasing representation in STEM pathways might also include an intervention during the first year that is aimed at helping students choose courses and make sense of their first-year STEM grades.

Finally, it is also important to consider the rates at which we might want students to consider STEM fields. While it perhaps would not be optimal for *all* students to study STEM, gatekeeping courses present a clear case of inequality because students with similar levels of background preparation and interest in STEM have different experiences.

Notes

1. All research reported here was approved by the Institutional Review Board at the University of Wisconsin-Madison. In the Wisconsin Center for Education Research (WCER) Pathways through College Research Network (PCRN) study, all human subjects gave their informed consent prior to their participation and adequate steps were taken to protect participants' confidentiality. The author used an anonymized version of the dataset to conduct the research presented here.
2. STEM majors include: Agriculture, Agriculture Operations and Related Sciences (including Animal Science, Food Science, and Soil Science); Natural Resources and Conservation; Computer and Information Sciences; Engineering, Engineering Technologies, and Engineering-Related Fields; Biological and Biomedical Sciences; Mathematics and Statistics; Physical Sciences; Science Technologies & Technicians; and Health Professionals and Related Programs.

Acknowledgments

I am grateful to Sam Wineburg and members of the Scholarly Writing Seminar, Mitchell Stevens, sean reardon, anthony antonio, Monique Harrison, Eric Grodsky, Chandra Muller, and members of the Pathways Through College Research Network for their feedback, comments, and assistance with this project. I am also grateful to the editor and anonymous reviewers for their feedback. All errors are my own.

Disclosure statement

No potential conflict of interest was reported by the author.

Funding

The research reported here was supported in part by the Institute of Education Sciences, U.S. Department of Education, through Grant R305B140009 to the Board of Trustees of the Leland Stanford Junior University, as well as the Pathways through College Research Network funded by the National Science Foundation under grant numbers DUE 1317196 and DUE 1317206. The opinions expressed are those of the author and do not represent views of the Institute, the U.S. Department of Education, the Board of Trustees of the Leland Stanford Junior University, or the National Science Foundation.

ORCID

Marissa E. Thompson http://orcid.org/0000-0002-9497-1400

References

Armstrong, E. A., & Hamilton, L. T. (2013). *Paying for the party: How college maintains inequality*. Harvard University Press.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice-Hall.

Bar, T., Kadiyali, V., & Zussman, A. (2009). Grade information and grade inflation: The cornell experiment. *Journal of Economic Perspectives*, *23*(3), 93–108. https://doi.org/10.1257/jep.23.3.93

Bui, K. V. T. (2002). First-generation college students at a four-year university: Background characteristics, reasons for pursuing higher education, and first-year experiences. *College Student Journal*, *36*(1), 3–11. http://psycnet.apa.org/psycinfo/2002-02801-001

Carnevale, A. P., Cheah, B., & Hanson, A. R. (2015). *The economic value of college majors*. Georgetown University Center on Education and the Workforce.

Cech, E. (2015). Engineers and engineeresses? Self-conceptions and the development of gendered professional identities. *Sociological Perspectives*, *58*(1), 56–77. https://doi.org/10.1177/0731121414556543

Chambliss, D. F., & Takacs, C. G. (2014). *How college works*. Harvard University Press.

Chang, M. J., Sharkness, J., Hurtado, S., & Newman, C. B. (2014). What matters in college for retaining aspiring scientists and engineers from underrepresented racial groups. *Journal of Research in Science Teaching*, *51*(5), 555–580. https://doi.org/10.1002/tea.21146

Chen, X., & Soldner, M. (2013). *STEM attrition: College students' path into and out of STEM fields*. National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC. https://doi.org/http://nces.ed.gov/pubs2014/2014001rev.pdf

Collier, P. J., & Morgan, D. L. (2008). "Is that paper really due today?" Differences in first-generation and traditional college students' understandings of faculty expectations. *Higher Education*, *55*(4), 425–446. https://doi.org/10.1007/s10734-007-9065-5

Correll, S. J. (2004). Constraints into preferences: Gender, status, and emerging career aspirations. *American Sociological Review*, *69*(1), 93–113. https://doi.org/10.1177/000312240406900106

Dika, S. L., & D'Amico, M. M. (2016). Early experiences and integration in the persistence of first-generation college students in STEM and non-STEM majors. *Journal of Research in Science Teaching*, *53*(3), 368–383. https://doi.org/10.1002/tea.21301

Eddy, S. L., Brownell, S. E., & Wenderoth, M. P. (2014). Gender gaps in achievement and participation inmultiple introductory biology classrooms. *CBE Life Sciences Education*, *13*(3), 478–492. https://doi.org/10.1187/cbe.13-10-0204

Fairlie, R. W. (2005). An extension of the blinder-oaxaca decomposition technique to logit and probit models. *Journal of Economics and Social Measurement*, *30*(4), 304–316. https://doi.org/10.3233/JEM-2005-0259

Fenske, R. H., Porter, J. D., & DuBrock, C. P. (2000). Tracking financial aid and persistence of women, minority, and needy students in science, engineering, and mathematics. *Research in Higher Education*, *41*(1), 67–94. https://doi.org/10.1023/A:1007042413040

Gasiewski, J. A., Eagan, M. K., Garcia, G. A., Hurtado, S., & Chang, M. J. (2012). From gatekeeping to engagement: A multicontextual, mixed method study of student academic engagement in introductory STEM courses. *Research in Higher Education*, *53*(2), 229–261. https://doi.org/10.1007/s11162-011-9247-y

Gayles, J. G., & Ampaw, F. (2016). To stay or leave: Factors that impact undergraduate women's persistence in science majors. *NASPA Journal about Women in Higher Education*, *9*(2), 133–151. https://doi.org/10.1080/19407882.2016.1213642

Gibbons, M. M., & Borders, L. D. (2010). Prospective first-generation college students : A social-cognitive perspective. *The Career Development Quarterly*, *58*(March), 194–208. https://doi.org/10.1002/j.2161-0045.2010.tb00186.x

Goldin, C. (2015). Notes on women and the undergraduate economics major. *CSWEP Newsletter*, *15*(Summer), 4–6.

Goyette, K. A., & Mullen, A. L. (2007). Who studies the arts and sciences? Social background and the choice and consequences of undergraduate field of study. *The Journal of Higher Education*, *77*(3), 497–538. https://doi.org/10.1353/jhe.2006.0020

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review*, *29*(6), 911–922. https://doi.org/10.1016/j.econedurev.2010.06.010

Grodsky, E., & Muller, C. (2018). *Pathways through college study* [Dataset]. University of Wisconsin.

Harackiewicz, J. M., Canning, E. A., Giffen, C. J., Blair, S. S., & Hyde, J. S. (2015). Closing the social class achievement gap for first-generation students in undergraduate biology. *Journal of Educational Psychology*, *106*(2), 375–389. https://doi.org/10.1037/a0034679.Closing

Jack, A. A. (2014). Culture shock revisited: The social and cultural contingencies to class marginality. *Sociological Forum*, *29*(2), 453–475. https://doi.org/10.1111/socf.12092

Jack, A. A. (2016). (No) Harm in asking: Class, acquired cultural capital, and academic engagement at an Elite University. *Sociology of Education*, *89*(1), 1–19. https://doi.org/10.1177/0038040715614913

Jones, E. B., & Jackson, J. D. (2006). College grades and labor market rewards. *The Journal of Human Resources*, *25*(2), 253. https://doi.org/10.2307/145756

Kokkelenberg, E. C., & Sinha, E. (2010). Who succeeds in STEM studies? An analysis of Binghamton University undergraduate students. *Economics of Education Review*, *29*(6), 935–946. https://doi.org/10.1016/j.econedurev.2010.06.016

Lent, R. W., Brown, S. D., & Hackett, G. (1994). Toward a unifying social cognitive theory of career and academic interest, choice, and performance. *Journal of Vocational Behavior*, *45*(1), 79–122. https://doi.org/10.1006/jvbe.1994.1027

Lent, R. W., Hackett, G., & Brown, S. D. (1999). A social cognitive view of school-to-work transition. *The Career Development Quarterly*, *47*(4), 297–311. https://doi.org/10.1002/j.2161-0045.1999.tb00739.x

Ma, Y. (2009). Family socioeconomic status, parental involvement, and college major choices — Gender, race/ ethnic,and nativity patterns. *Sociological Perspectives*, *52*(2), 211–234. https://doi.org/10.1525/sop.2009.52.2.211.212

Ma, Y., & Liu, Y. (2017). Entry and degree attainment in STEM: The intersection of gender and race/ethnicity. *Social Sciences*, *6*(3), 89. https://doi.org/10.3390/socsci6030089

Main, J. B., & Ost, B. (2014). The impact of letter grades on student effort, course selection, and major choice: A regression-discontinuity analysis. *The Journal of Economic Education*, *45*(1), 1–10. https://doi.org/10.1080/00220485.2014.859953

Mize, T. D. (2019). Best practices for estimating, interpreting, and presenting nonlinear interaction effects. *Sociological Science*, *6*, 81–117. http://dx.doi.org/10.15195/v6.a4

Mullen, A. L., Goyette, K. A., & Soares, J. A. (2003). Who goes to graduate school? Social and academic correlates of educational continuation after college. *Sociology of Education*, *76*(2), 143. https://doi.org/10.2307/3090274

Ost, B. (2010). The role of peers and grades in determining major persistence in the sciences. *Economics of Education Review*, *29*(6), 923–934. https://doi.org/10.1016/j.econedurev.2010.06.011

Owen, A. L. (2010). Grades, gender, and encouragement: A regression discontinuity analysis. *The Journal of Economic Education*, *41*(3), 217–234. https://doi.org/10.1080/00220485.2010.486718

Pascarella, E. T., Pierson, C. T., Wolniak, G. C., & Terenzini, P. T. (2004). First-generation college students: Additional evidence on college experiences and outcomes. *The Journal of Higher Education*, *75*(3), 249–284. https://doi.org/10.1353/jhe.2004.0016

Pattison, E., Grodsky, E., & Muller, C. (2013). Is the sky falling? Grade inflation and the signaling power of grades. *Educational Researcher*, *42*(5), 259–265. https://doi.org/10.3102/0013189X13481382

Quadlin, N. (2018). The mark of a woman's record: Gender and academic performance in hiring. *American Sociological Review*, *83*(2), 331–360. https://doi.org/10.1177/0003122418762291

Ramos-Sánchez, L., & Nichols, L. (2007). Self-efficacy of first-generation and non-first-generation college students: The relationship with academic performance and college adjustment. *Journal of College Counseling*, *10*(1), 6–18. https://doi.org/10.1002/j.2161-1882.2007.tb00002.x

Rask, K. (2010). Attrition in STEM fields at a liberal arts college: The importance of grades and pre-collegiate preferences. *Economics of Education Review*, *29*(6), 892–900. https://doi.org/10.1016/j.econedurev.2010.06.013

Rask, K., & Tiefenthaler, J. (2008). The role of grade sensitivity in explaining the gender imbalance in undergraduate economics. *Economics of Education Review*, *27*(6), 676–687. https://doi.org/10.1016/j.econedurev.2007.09.010

Redford, J., & Hoyer, K. M. (2017). *First-generation and continuing-generation college students: A comparison of high school and postsecondary experiences*. Stats in Brief. https://nces.ed.gov/pubs2018/2018009.pdf

Sabot, R., & Wakeman-Linn, J. (1991). Grade inflation and course choice. *Journal of Economic Perspectives*, *5*(1), 159–170. https://doi.org/10.1257/jep.5.1.159

Sanabria, T., & Penner, A. (2017). Weeded out? Gendered responses to failing calculus. *Social Sciences*, *6*(2), 47. https://doi.org/10.3390/socsci6020047

Seymour, E., & Hewitt, N. (1997). *Talking about leaving: Why undergraduates leave the sciences*. Westview Press.

Sirin, S. R. (2005). Socioeconomic status and academic achievement : A meta-analytic review of research. *Review of Educational Research*, *75*(3), 417–453. https://doi.org/10.3102/00346543075003417

Stephens, N. M., Fryberg, S. A., Markus, H. R., Johnson, C. S., & Covarrubias, R. (2012). Unseen disadvantage: How American universities' focus on independence undermines the academic performance of first-generation college students. *Journal of Personality and Social Psychology*, *102*(6), 1178–1197. https://doi.org/10.1037/a0027143

Stephens, N. M., Hamedani, M. Y. G., & Destin, M. (2014). Closing the social-class achievement gap: A difference-education intervention improves first-generation students' academic performance and all students' college transition. *Psychological Science*, *25*(4), 943–953. https://doi.org/10.1177/0956797613518349

Stinebrickner, T. R., & Stinebrickner, R. (2011). *Math or science? Using longitudinal expectations data to examine the process of choosing a college major* (NBER Working Paper No. 16189). National Bureau of Economic Research. https://www.nber.org/papers/w16869

Stinebrickner, T. R., & Stinebrickner, R. (2012). Learning about academic ability and the college dropout decision. *Journal of Labor Economics*, *30*(4), 707–748. https://doi.org/10.1086/666525

Swecker, H. K., Fifolt, M., & Searby, L. (2013). Academic advising and first-generation college students: A quantitative study on student retention. *NACADA Journal*, *33*(1), 46–53. https://doi.org/10.12930/NACADA-13-192

Toutkoushian, R. K., Stollberg, R. A., & Slaton, K. A. (2018). Talking 'bout my generation: Defining "first-generation college students" in higher education research. *Teachers College Record*, *120*(4), 1–38.

Tyson, W., Lee, R., Borman, K. M., & Hanson, M. A. (2007). Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and post-secondary degree attainment. *Journal of Education for Students Placed at Risk*, *12*(3), 243–270. https://doi.org/10.1080/10824660701601266

Warburton, E. C., Nuñez, A., & Carroll, C. D. (2001). *Bridging the gap: Academic preparation and postsecondary success of first-generation students*. National Center for Education Statistics, U.S. Department of Education. https://doi.org/NCES2001-153

Whalen, D. F., & Shelley, M. C. (2010). Academic success for STEM and non-STEM majors. *Journal of STEM Education*, *11*(1), 45–60.

Witherspoon, E. B., Vincent-Ruz, P., & Schunn, C. D. (2019). When making the grade isn't enough: The gendered nature of premed science course attrition. *Educational Researcher*, *48* (May), 0013189X1984033. https://doi.org/10.3102/0013189x19859593

Zafar, B. (2013). College major choice and the gender gap. *The Journal of Human Resources*, *48*(3), 545–595. https://doi.org/10.3368/jhr.48.3.545