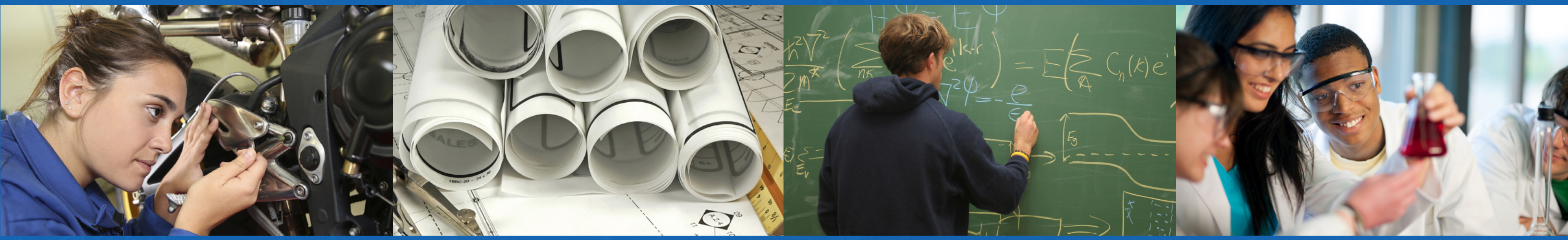
STEM Attrition: College Students' Paths Into and Out of STEM Fields

Statistical Analysis Report



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NOVEMBER 2013

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Executive Summary

Producing sufficient numbers of graduates who are prepared for science, technology, engineering, and mathematics (STEM) occupations has become a national priority in the United States. To attain this goal, some policymakers have targeted reducing STEM attrition in college, arguing that retaining more students in STEM fields in college is a low-cost, fast way to produce the STEM professionals that the nation needs (President's Council of Advisors on Science and Technology [PCAST] 2012). Within this context, this Statistical Analysis Report (SAR) presents an examination of students' attrition from STEM fields over the course of 6 years in college using data from the 2004/09 Beginning Postsecondary Students Longitudinal Study (BPS:04/09) and the associated 2009 Postsecondary Education Transcript Study (PETS:09). In this SAR, the term *STEM attrition* refers to enrollment choices that result in potential STEM graduates (i.e., undergraduates who declare a STEM major) moving away from STEM fields by switching majors to non-STEM fields or leaving postsecondary education before earning a degree or certificate.[1] The purpose of this study is to gain a better understanding of this attrition by:

- determining rates of attrition from STEM and non-STEM fields;
- identifying characteristics of students who leave STEM fields;
- comparing the STEM coursetaking and performance of STEM leavers and persisters; and
- examining the strength of various factors' associations with STEM attrition.

Data from a cohort of students who started their postsecondary education in a bachelor's or associate's degree program in the 2003–04 academic year were used to examine students' movement into and out of STEM fields over the subsequent 6 years through 2009. Analyses were performed separately for beginning bachelor's and associate's degree students. For brevity, these two groups are frequently referred to as *bachelor's* or *associate's degree students* in this study. Selected findings from this SAR are described below.

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[1] In this study, STEM major fields include mathematics; physical sciences; biological/life sciences; computer and information sciences; engineering and engineering technologies; and science technologies. For a detailed list of the fields designated as STEM in this SAR, see appendix C.

STEM Entrance

About 28 percent of bachelor's degree students and 20 percent of associate's degree students entered a STEM field (i.e., chose a STEM major) at some point within 6 years of entering postsecondary education in 2003–04. At the bachelor's degree level, biological/life sciences was the most popular field, attracting 11 percent of students, and mathematics and physical sciences were the two least popular fields, attracting 2–3 percent of students. At the associate's degree level, a higher percentage of students chose computer/information sciences (9 percent) than other STEM fields (1–6 percent).

Attrition Rates in STEM and Non-STEM Fields

Many of these STEM entrants left STEM several years later by either changing majors or leaving college without completing a degree or certificate. A total of 48 percent of bachelor's degree students and 69 percent of associate's degree students who entered STEM fields between 2003 and 2009 had left these fields by spring 2009. Roughly one-half of these leavers switched their major to a non-STEM field, and the rest of them left STEM fields by exiting college before earning a degree or certificate.

Attrition rates in non-STEM fields were as high as or higher than those in STEM fields. At the bachelor's degree level, students in humanities, education, and health sciences had higher attrition rates (56–62 percent) than did those in STEM fields (48 percent), and students in business and social/behavioral sciences had comparable attrition rates (50 and 45 percent, respectively) as did students in STEM fields. A closer look at how students left their fields reveals that proportionally more students in education (42 percent) and health sciences (35 percent) switched majors than did students in STEM fields (28 percent).

At the associate's degree level, students in selected non-STEM fields had attrition rates ranging from 57 percent in health sciences and 66 percent in business to 70 percent in education and 72 percent in humanities. These rates were generally comparable to that in STEM fields (69 percent). Proportionally more students in STEM fields (33 percent), however, switched majors than did students in business (26 percent) and health sciences (20 percent).

Important Factors Associated With STEM Attrition

In this study, a multinomial probit (MNP) model was used to examine how various factors were associated with STEM attrition, after controlling for related factors. This model was used because the outcomes of STEM entrants can fall into multiple categories—that is, they can persist and eventually earn a degree in a STEM field, they can switch majors and pursue a non-STEM field, or they can quit school entirely without earning a degree or certificate.

While a bivariate analysis showed that STEM attrition was correlated with a wide range of factors, including students' demographic characteristics, precollege academic preparation, types of first institution enrolled, and STEM coursetaking and performance, the MNP analysis examined all these factors simultaneously and revealed more information than what bivariate analysis could yield. In terms of switching majors to non-STEM fields, the MNP results showed that the intensity of STEM coursetaking in the first year, the type of math courses taken in the first year, and the level of success in STEM courses bore stronger associations with this outcome than did many other factors. Specifically, taking lighter credit loads in STEM courses in the first year, taking less challenging math courses in the first year, and performing poorly in STEM classes relative to non-STEM classes were associated with an increased probability of switching majors for STEM entrants at both the bachelor's and associate's degree levels. Accumulating higher levels of withdrawn/failed STEM credits was also a critical factor for switching majors among bachelor's degree STEM entrants.

With respect to the outcome of leaving college without earning a degree or certificate, the MNP results showed that STEM entrants' overall college performance and their level of success in STEM courses were better predictors than many other factors. Poor performance in college (as reflected by a lower cumulative grade point average [GPA] through 2009) and high levels of withdrawn/failed STEM courses were associated with an increased probability of dropping out of college for both bachelor's and associate's STEM entrants. Less success in STEM courses than in non-STEM courses (as reflected by earning lower STEM grades relative to non-STEM grades) was also associated with an increased probability of dropping out of college for STEM entrants at the associate's degree level.

The MNP analysis also revealed several other patterns that were different from those in the bivariate results. While the bivariate analysis showed that female STEM entrants at both degree levels left STEM fields more frequently by switching majors than their male counterparts, the MNP analysis yielded this result only among associate's degree students. In addition, the bivariate analysis showed that at the associate's degree level, STEM entrants from various income backgrounds had similar rates of leaving STEM fields by switching majors; after controlling for the other variables in the MNP model, however, those from low-income backgrounds were found to have a lower probability of switching majors than their counterparts from high-income backgrounds.

The MNP results further indicated that low- and high-performing STEM entrants may exit STEM fields in different ways. At both the bachelor's and associate's degree level, the probability of exiting STEM fields by dropping out of college was higher for low-performing students (i.e., those with an overall college GPA of less than 2.5) than for high-performing students (i.e., those with an overall college GPA of 3.5 or higher), while the probability of leaving STEM fields by switching majors was higher for students in the high-performing group than for their peers in the low-performing group. More research is needed to understand the underlying motivation for leaving STEM fields, particularly among top students.

Finally, the MNP analysis confirmed several patterns observed among bachelor's degree STEM entrants in the bivariate analysis. All other factors being equal, bachelor's degree STEM entrants who first attended public 4-year institutions had a higher probability of leaving STEM by switching majors than those who started at private nonprofit 4-year institutions. Bachelor's degree STEM entrants who were male or who came from low-income backgrounds had a higher probability of leaving STEM by dropping out of college than their peers who were female or came from high-income backgrounds, net of other factors. Similarly, bachelor's degree STEM entrants who first attended institutions that were among the least selective had a higher probability of leaving STEM due to dropping out than students who first attended highly selective institutions.

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Introduction

Science, technology, engineering, and mathematics (STEM) fields are widely regarded as vital to a nation's economy. While the United States has long been held as a world leader in scientific and technological innovation, it is facing fierce competition from abroad in producing and retaining STEM talent (National Science Board 2010a). Various sources show that:

- the mathematics and science performance of U.S. elementary and secondary students lags behind their peers in many other nations (Fleischman et al. 2010; Gonzales et al. 2008; Provasnik et al. 2012);
- the rates at which U.S. undergraduates choose STEM majors trail those of several key competitors (National Science Board 2010b);
- the United States has one of the lowest ratios of STEM to non-STEM bachelor's degrees in the world (National Science Board 2012); and
- top U.S. students, who have great potential to become future science and technology innovators, are eschewing careers in STEM fields (Bettinger 2010; Lowell et al. 2009; Zumeta and Raveling 2002).

Rising concerns about the ability of the United States to compete in the global economy have led to numerous calls for national efforts to increase the number and diversity of students pursuing degrees and careers in STEM fields (National Academy of Science 2005; National Governors Association 2007; National Research Council 2012; National Science Board 2007). In 2009, the Obama administration launched the "Educate to Innovate" campaign to improve the participation and performance of U.S. students in STEM (The White House n.d.). The U.S. Department of Commerce projects that STEM employments will grow faster than non-STEM employment.[2] A recent policy report by the President's Council of Advisors on Science and Technology (PCAST 2012) urged colleges and universities at all levels to produce more STEM graduates, announcing that if the United States is to retain its preeminence in science and technology and remain competitive in a fast-changing economy, it will need 1 million more STEM professionals over the next decade than it is currently projected to produce.

[2] The U.S. Department of Commerce projects that STEM employment will grow 17 percent between 2008 and 2018 while non-STEM employment will grow at a slower pace, increasing by 10 percent (Langdon et al. 2011).

Background

Postsecondary education plays a critical role in building a strong STEM workforce for the future. The U.S. postsecondary education system, however, frequently loses many potential STEM graduates. National data revealed that more than half of freshmen who declared STEM majors at the start of college left these fields before graduation (Chen 2009; Higher Education Research Institute 2010), and more than half of STEM bachelor's degree recipients switched to non-STEM fields when they entered graduate school or the labor market (Lowell et al. 2009; National Science Board 2012). Other studies indicated that many STEM leavers were actually high-performing students who might have made valuable additions to the STEM workforce had they stayed in STEM fields (Seymour and Hewitt 1997; Lowell et al. 2009). To produce more graduates in STEM fields, some recent U.S. policies have focused on reducing students' attrition from STEM fields in college, arguing that increasing STEM retention by even a small percentage can be a cost-efficient way to contribute substantially to the supply of STEM workers (Ehrenberg 2010; Haag and Collofello 2008; PCAST 2012).

In light of our nation's need to build a strong STEM workforce for the future, an examination of STEM attrition in U.S. postsecondary education is warranted. Using data from the 2004/09 Beginning Postsecondary Students Longitudinal Study (BPS:04/09), this Statistical Analysis Report (SAR) tracks a cohort of 2003–04 beginning postsecondary students over 6 years (from 2003 to 2009), presenting the most recent national statistics on STEM attrition in college. Capitalizing on the transcript data collected through BPS:04/09, this study also provides a first look at STEM coursetaking at the national level, detailing how participation and performance in undergraduate STEM coursework are associated with STEM attrition. Throughout this study, the term *STEM attrition* is used to refer to enrollment choices that result in potential STEM graduates (i.e., those who declare a STEM major) leaving STEM fields. STEM attrition can occur at any time in college. The purpose of this SAR is to deepen understanding of this attrition by addressing the following questions:

- What is the STEM attrition rate in postsecondary education? Is it higher than attrition rates in other fields?
- Who leaves STEM fields? Into which fields do they move?
- Do STEM leavers and persisters differ in terms of their STEM coursetaking and performance?
- How are various student, high school, and postsecondary institutional and coursetaking characteristics associated with STEM attrition when taking into

account interrelated factors? Which factors are most associated with STEM attrition?

To address these questions, this SAR is organized into three main sections. The first section focuses on the first two questions, presenting nationally representative statistics on STEM entrance and attrition rates, comparing attrition rates between STEM and non-STEM fields, and examining the characteristics of students who leave STEM fields and the fields into which they move. The second section takes a closer look at STEM coursetaking and performance, determining whether coursetaking patterns and grades of STEM leavers differed from those of STEM persisters. Built on bivariate results in the prior sections, the third section makes use of a multinomial probit model to examine the associations of various factors with STEM attrition, while taking into account the interrelationship of these factors.

To provide a context for the analysis, the following section presents a brief review of research literature, defines several key terms used in this study, describes the data sources and sample used for the analysis, and discusses some limitations of this study.

Literature Review

Although one-third of freshmen express interest in STEM majors before starting college (National Science Board 2012), the actual STEM enrollment rate is lower: for instance, STEM majors accounted for just 14 percent of all undergraduates enrolled in U.S. postsecondary education in 2007–08 (Snyder and Dillow 2011). For various reasons, a significant proportion of students who initially intend to study STEM fields abandon them several years later. A recent study found that a total of 56 percent of postsecondary students who declared STEM majors in their freshman year left these fields over the next 6 years (Chen 2009). Although attrition rates of similar magnitude were reported elsewhere (Bettinger 2010; Goulden, Frasch, and Mason 2009; Kokkelenberg and Sinha 2010; Lowell et al. 2009), little research has compared attrition rates across different fields to determine whether high attrition is unique to STEM fields or appears in other fields as well.

A number of plausible factors may underlie STEM attrition. Studies have frequently found that women, underrepresented minorities,[3] first-generation students,[4] and those from low-income backgrounds leave STEM fields at higher rates than their counterparts (Anderson and Kim 2006; Hill, Corbett, and Rose 2010; Griffith 2010; Huang, Taddese, and Walter 2000; Kokkelenberg and Sinha 2010; Shaw and

[3] Blacks, Hispanics, and American Indians/Alaska Natives.

[4] Students who are the first members of their families to attend college.

Barbuti 2010). In addition, STEM attrition occurs more frequently among students with weaker academic backgrounds (Astin and Astin 1992; Kokkelenberg and Sinha 2010; Mendez et al. 2008; Shaw and Barbuti 2010; Strenta et al. 1994; Whalen and Shelley 2010). Next, there is evidence linking STEM attrition to such attitudinal factors as motivation, confidence, and beliefs about one's capacity to learn STEM subjects (Burtner 2005; Huang, Taddese, and Walter 2000). Finally, STEM degrees often take longer to complete than other degrees, so financial aid may take on added importance in retaining students in STEM programs (Fenske, Porter, and DuBrock 2000; Whalen and Shelley 2010).

Anecdotal evidence and small-scale studies have identified several course-related factors that may explain why students lose their interest in STEM programs, including negative experiences encountered in gatekeeper or introductory math and science courses[5] (Barr, Gonzalez, and Wanat 2008; Crisp, Nora, and Taggart 2009; Mervis 2010; Seymour 2001; Seymour and Hewitt 1997; Thompson et al. 2007); limited exposure to STEM coursework in the first 2 years (Bettinger 2010); and poor performance in STEM courses, especially relative to performance in non-STEM courses (Ost 2010; Rask 2010; Seymour and Hewitt 1997; Stinebrickner and Stinebrickner 2011). These findings, however, have not been extensively investigated using nationally representative data.

Students' experiences or perceptions of institution and workplace context/climate may be related to STEM attrition as well. Such factors include inadequate academic advising, career counseling, and institution support; feelings of isolation in STEM fields because too few peers pursue STEM degrees and too few role models and mentors are available (mainly pertinent to females and underrepresented minorities); distaste for the competitive climate in STEM departments (women especially); and perceived discrimination on the basis of sex and/or race/ethnicity in the STEM workforce (Blickenstaff 2005; Carrell, Page, and West 2010; Chang et al. 2011; Daempfle 2003; Eagan et al. 2011a; Espinosa 2011; Fouad et al. 2010; Ost 2010; Price 2010; Seymour 2001; Thompson et al. 2007). These contextual and climate factors are now accepted as areas worthy of investigation for explaining the departure of students (especially women and minorities) from STEM fields at various points in college.

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[5] Such negative experiences may include, for example, large class sizes, passive learning techniques, lack of direct contact with faculty, language barriers associated with international instructors or teaching assistants, and faculty being perceived as valuing their research above teaching. Some of the gatekeeper courses may be purposely designed to be rigorous and unsupportive as a way to filter out the weakest students (Eagan et al. 2011b).

The review of past research suggests that students' decisions to leave STEM fields are likely to arise from a multitude of factors, underscoring the need to examine models of STEM attrition that include multiple factors simultaneously. In light of this review, the analyses presented in this SAR encompass as many related factors as available in BPS:04/09. Past research has already provided extensive insights into demographic and prior college characteristics; therefore, this study pays special attention to STEM coursetaking and performance in college. Although it is not possible in this analysis to determine exactly how students' curricular experiences affect their decisions to leave STEM fields, the study represents a first step toward understanding the relationship between coursetaking and STEM attrition using nationally representative data.

Definition of Key Terms

To facilitate discussions of the analysis and its results, the following provides the definitions of key terms used in this study.

STEM fields can include a wide range of disciplines.[6] In this study, the following fields are classified as STEM: mathematics; physical sciences; biological/life sciences; computer and information sciences; engineering and engineering technologies; and science technologies.[7] For a detailed list of the fields designated as STEM in this SAR, see appendix C.

Non-STEM fields, by definition, include all fields that are not STEM fields. Rather than combining all non-STEM fields into one group, this study specifically compares STEM fields with the following five fields: social/behavioral sciences; humanities; business; education; and health sciences, because these fields had adequate sample sizes for analysis in BPS:04/09. For more detail on the fields in each major category, see appendix C.

STEM entrance is used to refer to a student's majoring in a STEM field of study in college. In BPS:04/09, STEM entrance can be identified at three points in time: during the 2004 base-year survey and during the 2006 and 2009 follow-up surveys. In this study, any student who reported a STEM major at one or more of these three points is considered a STEM entrant between 2003 and 2009.

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[6] As an example, see the National Science Foundation (NSF) definitions of these fields at http://www.nsf.gov/statistics/nsf11316.

[7] Due to small sizes of sampled students, science technology majors were combined with engineering/engineering technology majors in this study. The resulting category is labeled as "engineering/technologies."

STEM leavers are a subgroup of STEM entrants who leave STEM fields either by switching their major to a non-STEM field or by leaving postsecondary education without earning a degree or certificate (for brevity, the latter group is frequently referred to as *students who dropped out of college* or *college dropouts* below). In BPS:04/09, STEM leavers consist of STEM entrants who (1) had not attained any degree or certificate by 2009 and were not enrolled in that year; (2) were enrolled in a non-STEM field in 2009; (3) were not enrolled in 2009 and had attained one or more degrees only in non-STEM fields; or (4) were not enrolled in 2009 and had attained more than one degree (one in a STEM field) but whose most recent degree was in a non-STEM field.[8]

STEM persisters are a subgroup of STEM entrants who remain in STEM fields throughout their college career. In BPS:04/09, STEM persisters consist of STEM entrants who either were enrolled in a STEM field in 2009 or, if not enrolled that year, had attained their most recent degree in a STEM field.

STEM attrition rate is the number of STEM leavers divided by the total number of STEM entrants.

Data Sources and Sample

Data Sources

The analysis described in this report is based on data from the 2004/09 Beginning Postsecondary Students Longitudinal Study (BPS:04/09) and the associated 2009 Postsecondary Education Transcript Study (PETS:09). BPS:04/09 followed a cohort of students who began postsecondary education in 2003–04 for a total of 6 years, through 2009. BPS sample members were initially identified in the 2003–04 National Postsecondary Student Aid Study (NPSAS:04).[9]

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[8] Fewer than 20 sampled beginning bachelor's and associate's degree students attained more than one degree by 2009, with one or more of these degrees in a STEM field. Most of them first attained a certificate or an associate's degree in a STEM field and then switched out of a STEM field and attained a bachelor's degree in a non-STEM field. Thus, it is reasonable to consider these students as STEM leavers though they have attained a STEM degree at some point during college. If students began as a STEM major and later transferred to another institution where they changed their major, they were considered to have switched majors.

[9] NPSAS:04 is a nationally representative sample of about 90,000 undergraduate, graduate, and first-professional students in about 1,600 postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico who are eligible to participate in federal Title IV student aid programs. It is a comprehensive study that examines how undergraduate, graduate, and first-professional students and their families pay for postsecondary education.

Approximately 19,000 NPSAS:04 sample members were confirmed as first-time beginning students. Interviews were then conducted three times: in 2004, at the end of their first year in postsecondary education; in 2006, about 3 years after their initial college entry; and in 2009, about 6 years after they first enrolled. Through student interviews and other sources, data on students' demographic characteristics; their persistence in and completion of postsecondary education programs; their transition into employment; and changes over time in their goals, marital status, income, and debt, among other indicators, were collected. The final BPS:04/09 dataset contains information on approximately 16,700 students.

In 2009, BPS:04/09 also collected transcript data from every institution that BPS students attended between July 2003 and June 2009. About 91 percent of the eligible students had at least one transcript available for analysis. The transcripts provide a detailed portrait of students' enrollment, coursetaking, credit accumulation, academic performance, and degree histories. More information about BPS:04/09 and its transcript component can be found in appendix B.

Sample

To provide a longitudinal look at STEM attrition over 6 years in college, this study focused on a subsample of BPS:04/09 students who participated in the initial survey in 2003–04 as well as in the two follow-up surveys in 2006 and 2009. Most STEM occupations require at least an associate's degree (Carnevale, Smith, and Melton 2011); therefore, the study sample was further restricted to students who began their postsecondary education in a bachelor's or associate's degree program.[10] These selections resulted in approximately 7,800 beginning bachelor's degree students and 5,600 beginning associate's degree students to be included in the analysis of this study.[11] Because these two groups of students had different STEM attrition rates, they were analyzed separately throughout this report. For brevity, beginning bachelor's or associate's degree students are frequently referred to as *bachelor's* or *associate's degree students* in this study, although some students later transferred to a different degree program (e.g., from an associate's to a bachelor's degree program).[12]

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[10] Sample sizes for students who started in a certificate program or who were not enrolled in any degree program were too small to produce reliable estimates.

[11] Only 103 beginning bachelor's degree students and 180 beginning associate's degree students in BPS:04/09 did not meet the selection criteria and were excluded from this study.

[12] Due to the small sample of STEM entrants, students were not further differentiated by their transfer status in this study. Students, whether they transferred or not, were put into an analysis group based on their initial degree program. For example, students who started in an associate's degree program were included in the analysis group for beginning associate's degree students, although some of them subsequently transferred to a bachelor's degree program.

Statistical Comparisons

All bivariate comparisons in this study were tested for statistical significance using a two-tailed Student's *t* statistic to ensure that the differences were larger than might be expected due to sampling variation. Unless specifically noted, all differences cited in the report were statistically significant at the .05 level. Adjustments were not made for multiple comparisons; consequently, some differences noted here might not be significant if a multiple comparison procedure was used. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

All bivariate estimates presented in this report are also available in the NCES Web Tables *STEM in Postsecondary Education: Entrance, Attrition, and Coursetaking Among 2003–04 Beginning Postsecondary Students*. It is available for download at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2013152 (Chen and Ho 2012).

Limitations

Readers are cautioned to keep four issues in mind when considering the findings reported here. First, this study draws upon students' reported major fields to identify STEM entrants. Because BPS:04/09 collected students' majors only at three time points and students could have had an unreported STEM major and STEM attrition could have occurred before the initial interview time[13] or between the three data collection points, the number of STEM entrants and the extent of STEM attrition may be underestimated.

Second, because BPS:04/09 is a general purpose survey on postsecondary education, its questions and survey elements were not tailored to include all variables relevant to research on STEM attrition. Some data identified in the literature as potentially important to STEM attrition (e.g., institutional context, climate, and support for STEM learning, characteristics of STEM faculty, STEM-related preparation and experiences in high school,[14] and noncognitive factors such as motivation, interest, confidence, and beliefs) were not collected (Barr, Gonzalez, and Wanat 2008; Burtner 2005; Chang et al. 2011; Crisp, Nora, and Taggart 2009; Daempfle 2003; Eagan et al. 2011a; Espinosa 2011; Price 2010; Seymour and Hewitt 1997). Consequently, the multivariate analysis in this study cannot control for all factors that have been shown in prior research to be related to STEM attrition.

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[13] The base-year data were collected around the end of the 2003–04 academic year.
[14] BPS:04/09 collected only one piece of STEM-related information in high school: the highest level of math coursetaking. This variable was included in both the bivariate and multivariate analyses for this report.

Third, past research suggests that there are some important distinctions among STEM fields. For example, biology/life sciences often attract proportionally more female students than “hard” sciences like physics, engineering, and computer sciences (National Science Board 2012); attrition rates vary across STEM fields, with relatively lower rates frequently occurring among engineering majors (Shaw and Barbuti 2010); and the determinants of departure decisions may not be the same across different STEM fields (Kokkelenberg and Sinha 2010; Ost 2010; Rask 2010). While it is ideal to differentiate specific STEM fields, such analysis is very limited in this study due to the small number of BPS:04/09 students entering some STEM disciplines.

Finally, this study is descriptive in nature. The purpose of the multivariate analysis in the last part of this report is not to validate a theoretical model or identify causal relationships. Rather, the intention of the model is to refine bivariate analyses, and more specifically, to examine the relative strength of associations between various factors and STEM attrition, while taking into account the interrelationships of these factors, which bivariate analysis cannot easily disentangle. Hence, while the multivariate results may suggest topics for further research that might be examined with other data sources or methods appropriate for causal analysis, they do not purport to identify causes of STEM attrition.

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STEM Entrance and Attrition in Postsecondary Education

This section begins with a brief overview of STEM entrance among a cohort of beginning postsecondary students. It then focuses on STEM attrition, providing descriptive statistics on the rates at which students enter and leave STEM fields, comparing attrition rates in STEM and non-STEM fields, and identifying the fields to which STEM leavers moved and the characteristics of STEM leavers.

STEM Entrance: A Brief Overview

Based on the major fields reported by beginning postsecondary students (BPS), about 28 percent[15] of 2003–04 beginning bachelor's degree students chose a STEM major at some point during their enrollment between 2003 and 2009 (figure 1).[16] STEM fields, as a total category, attracted proportionally more bachelor's degree students (28 percent) than did many non-STEM fields examined in this study, including social/behavioral sciences, humanities, education, and health sciences (13–21 percent). Only business had a similar entrance rate (26 percent). Within STEM fields, biological/life sciences was the most popular field, attracting 11 percent of bachelor's degree students, while mathematics and physical sciences were the two least popular fields, with 2–3 percent of students entering these two fields.

Compared with bachelor's degree students (28 percent), proportionally fewer associate's degree students entered STEM fields at some point during their enrollment from 2003 to 2009 (20 percent). Proportionally more associate's degree students entered business or health sciences (25 percent each) than STEM fields (20 percent), and among STEM fields, a higher percentage chose computer/information sciences (9 percent) than other STEM fields (1–6 percent).

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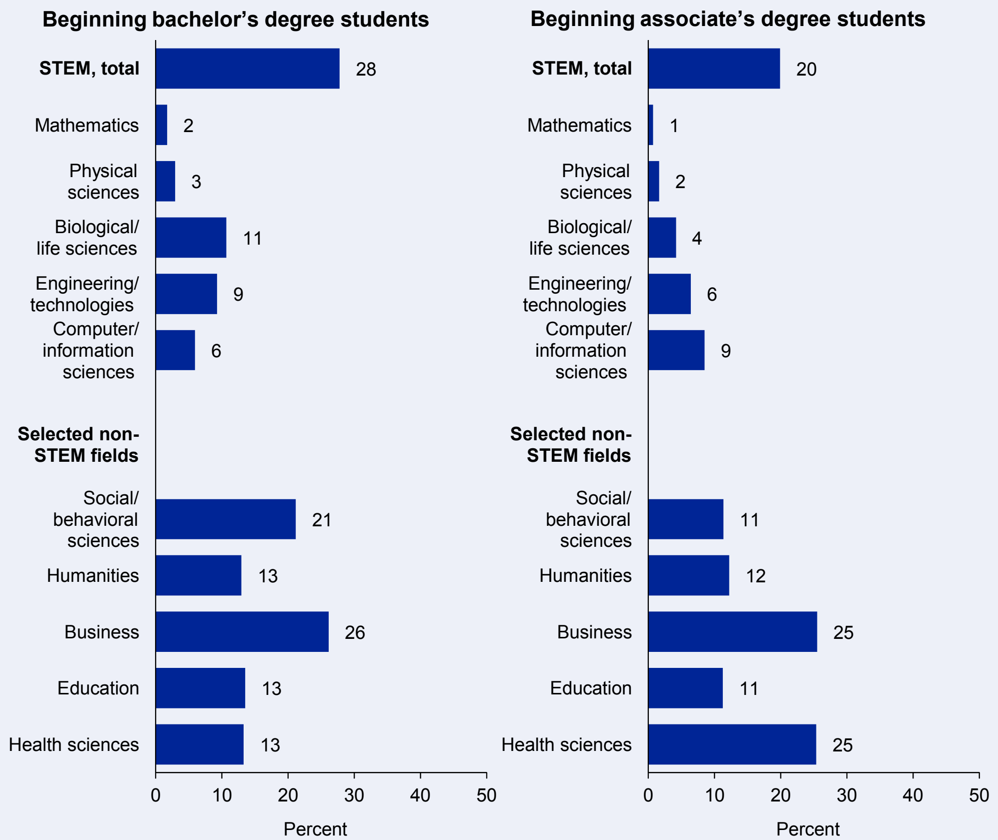
[15] This estimate is higher than those reported elsewhere (e.g., Snyder and Dillow 2011) because it captured STEM entrance at three time points over 6 years rather than as a one-time snapshot.
[16] Using data from the 1996/01 Beginning Postsecondary Students Longitudinal Study (BPS:96/01), an earlier study (Chen 2009) found that proportionally more male students, younger and dependent students, Asian/Pacific Islander students, foreign students or those who spoke a language other than English as a child, and students with advantaged family backgrounds and strong academic preparation entered STEM fields (i.e., chose a STEM major) than their counterparts who did not have these characteristics.

Figure 1.
Percentage of 2003–04 beginning bachelor's and associate's degree students who entered STEM and selected non-STEM fields: 2003–2009



NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Due to small sample sizes, science technology majors were combined with engineering/engineering technology majors. The resulting category is labeled as "engineering/technologies." Social/behavioral sciences include economics, geography, international relations and affairs, political science and government, sociology, psychology, history, and other social sciences. Humanities include English language/literature/letters, foreign languages/literatures/linguistics, liberal arts and sciences/general studies/humanities, area/ethnic/cultural/gender studies, and philosophy/theology/religious studies. Business includes business, management, marketing, and related support services. Health sciences include health professions and related sciences, and residency programs. Estimates for entering specific STEM fields do not sum to the total because some students entered more than one STEM field between 2003 and 2009. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.
SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09).

Most students who entered STEM fields did so during the first year (64 percent for bachelor's degree students and 59 percent for associate's degree students) (table 1). However, the timing of entrance varied widely across STEM disciplines. While a majority of bachelor's degree students who entered engineering/technologies did so during the first year (77 percent), most students who entered mathematics and physical sciences did so after the first year (64 and 67 percent, respectively). For associate's degree students, a majority of those who entered computer/information sciences and engineering/technologies did so in the first year (63 and 58 percent, respectively). However, 78 percent of those who entered physical sciences did so after their first year.

Table 1.
Among 2003–04 beginning bachelor's and associate's degree students who entered STEM and selected non-STEM fields, percentage distribution of their entrance time into these fields, by major field entered: 2003–2009

Major field entered between 2003 and 2009	Beginning bachelor's degree students		Beginning associate's degree students	
	During first year[1]	After first year[2]	During first year[1]	After first year[2]
STEM field, total	63.8	36.2	59.1	40.9
Mathematics	35.7	64.3	47.2	52.8
Physical sciences	32.6	67.4	21.8 !	78.2
Biological/life sciences	53.4	46.6	48.2	51.8
Engineering/technologies[3]	77.3	22.7	58.2	41.8
Computer/information sciences	55.7	44.3	62.8	37.2
Selected non-STEM field				
Social/behavioral sciences	35.5	64.5	35.1	64.9
Humanities	32.7	67.3	44.2	55.8
Business	50.8	49.2	52.5	47.5
Education	60.0	40.0	58.5	41.5
Health sciences	60.4	39.6	64.9	35.1

! Interpret data with caution. Estimate is unstable because the standard error represents more than 30 percent of the estimate.

[1] In the 2003–04 academic year.

[2] Between 2004–05 and 2008–09 academic years.

[3] Due to small sample sizes, science technology majors are combined with engineering/engineering technology majors, and the resulting category is labeled as "engineering/technologies."

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Social/behavioral sciences include economics, geography, international relations and affairs, political science and government, sociology, psychology, history, and other social sciences. Humanities include English language/literature/letters, foreign languages/literatures/linguistics, liberal arts and sciences/general studies/humanities, area/ethnic/cultural/gender studies, and philosophy/theology/religious studies. Business includes business, management, marketing, and related support services. Health sciences include health professions and related sciences, and residency programs. Detail may not sum to totals because of rounding. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09).

Attrition Rates in STEM and Non-STEM Fields

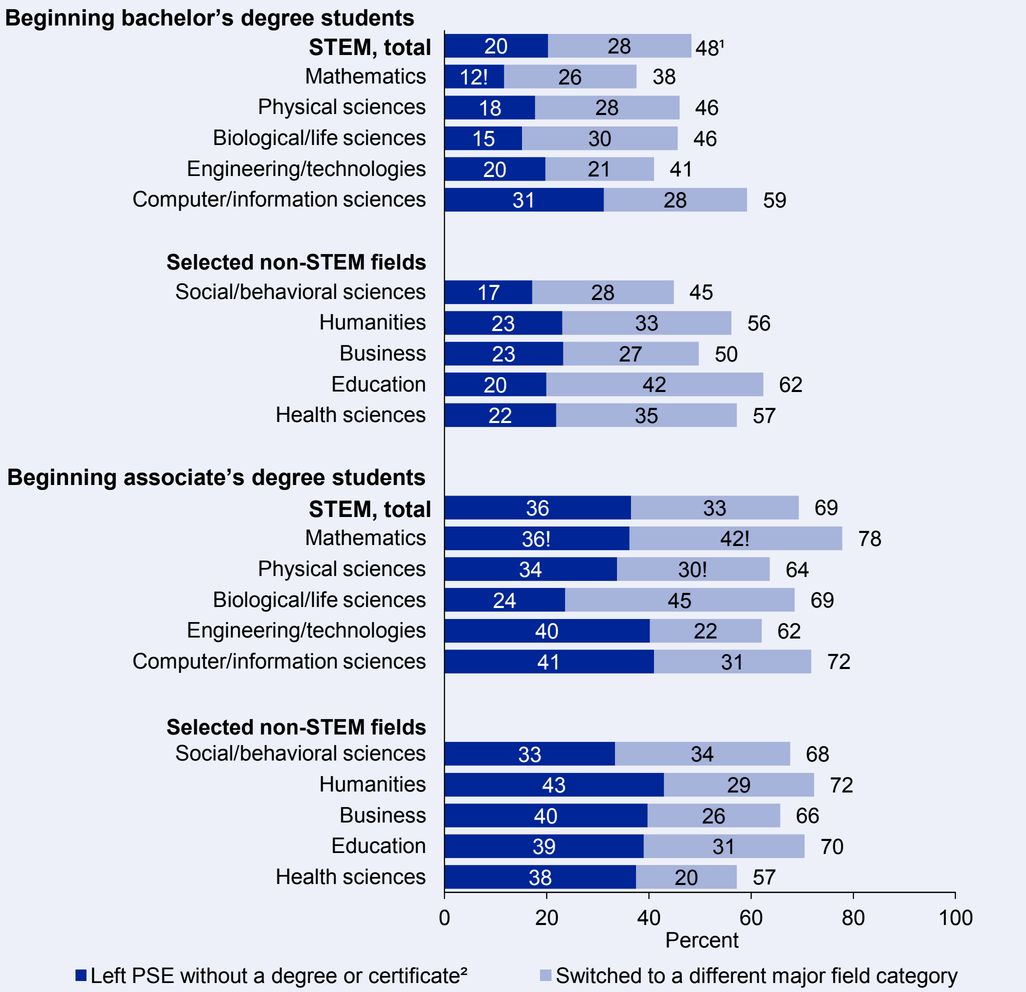
Among bachelor's degree students entering STEM fields between 2003 and 2009, nearly one-half (48 percent) had left these fields by spring 2009 (figure 2). Some left STEM fields by switching their major to a non-STEM field (28 percent), while others exited college entirely without earning a degree or certificate (20 percent). Attrition rates varied across STEM disciplines, ranging from 38 percent among mathematics majors to 59 percent among computer/information sciences majors.

STEM attrition was more common among associate's degree students than among bachelor's degree students: about 7 in 10 associate's degree students (69 percent) entering STEM fields between 2003 and 2009 had left these fields by spring 2009. Nearly half of these leavers had switched to a non-STEM major. Among STEM fields, attrition rates ranged from 62 percent among engineering/technology majors to 78 percent among mathematics majors.

Students in many non-STEM fields experienced similar or higher attrition rates (figure 2). At the bachelor's degree level, for example, students in humanities, health sciences, and education had higher attrition rates than did those in STEM fields (56–62 percent vs. 48 percent). Students in business and social/behavioral sciences had similar attrition rates (50 percent and 45 percent, respectively) as did students in STEM fields. Furthermore, switching majors was more common among students majoring in education (42 percent) and in health sciences (35 percent) than in STEM fields (28 percent).

Attrition was also high among students in many non-STEM fields at the associate's degree level, ranging from 57 percent in health sciences and 66 percent in business to 70 percent in education and 72 percent in humanities. All rates (with the exception of the rate in health sciences) were comparable to that in STEM fields (69 percent). However, proportionally more associate's degree students in STEM fields (33 percent) switched majors than did students in business and in health sciences (26 percent and 20 percent, respectively).

Figure 2.
Percentage of 2003−04 beginning bachelor's and associate's degree students who left STEM and selected non-STEM fields after their entrance into these fields, by major field entered: 2003−2009



! Interpret data with caution. Estimate is unstable because the standard error represents more than 30 percent of the estimate.

[1] Total STEM attrition rate which is the sum of the percentage of STEM entrants who switched majors to non-STEM fields and the percentage who left PSE without earning a degree or certificate. Total attrition rates in other fields were calculated in the same way.

[2] "Students who left PSE without a degree or certificate" are also referred to as students who dropped out of college or college dropouts in the text.

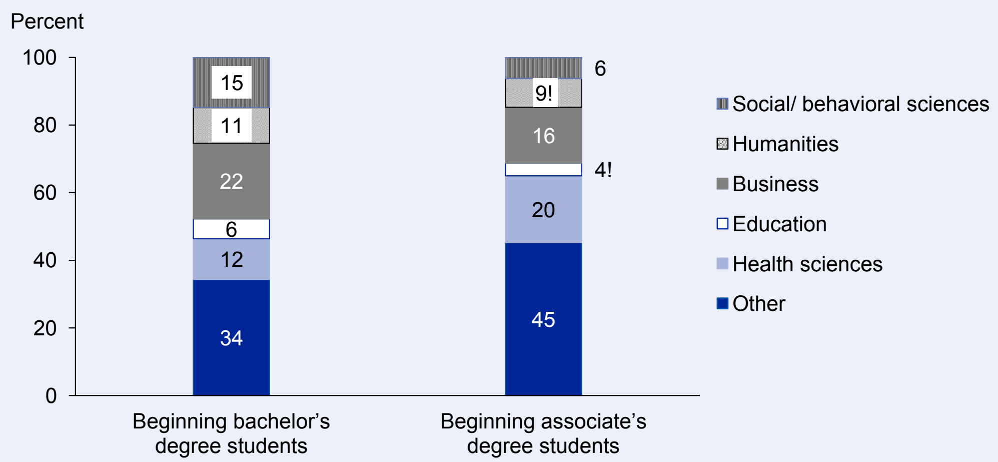
NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Due to small sample sizes, science technology majors were combined with engineering/engineering technology majors. The resulting category is labeled as "engineering/technologies." Social/behavioral sciences include economics, geography, international relations and affairs, political science and government, sociology, psychology, history, and other social sciences. Humanities include English language/literature/letters, foreign languages/literatures/linguistics, liberal arts and sciences/general studies/humanities, area/ethnic/cultural/gender studies, and philosophy/theology/religious studies. Business includes business, management, marketing, and related support services. Health sciences include health professions and related sciences, and residency programs. "PSE" refers to postsecondary education. Students who switched majors within a broad major category (e.g., from math to physics within STEM or from finance to marketing within business) are not considered as leavers from that broad major category. Detail may not sum to totals because of rounding. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

Destination for Major Switchers

Figure 3 displays the last major field reported by switchers, showing that business was one of the most popular destinations: 22 percent of bachelor's degree students and 16 percent of associate's degree students who entered STEM fields and later switched majors ended up pursuing business. The field of health sciences was also a popular destination among associate's degree students: 20 percent of those who entered STEM fields and later switched majors ended up in a health science field. Education, on the other hand, was one of the least popular destinations for STEM leavers: 6 percent of bachelor's degree students and 4 percent of associate's degree students who entered STEM fields and later switched fields ended up in education.

Figure 3.
Percentage distribution of the last major field among 2003–04 beginning bachelor's and associate's degree students who entered STEM fields and later switched to non-STEM fields: 2003–2009



! Interpret data with caution. Estimate is unstable because the standard error represents more than 30 percent of the estimate.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Social/behavioral sciences include economics, geography, international relations and affairs, political science and government, sociology, psychology, history, and other social sciences. Humanities include English language/literature/letters, foreign languages/literatures/linguistics, liberal arts and sciences/general studies/humanities, area/ethnic/cultural/gender studies, and philosophy/theology/religious studies. Business includes business, management, marketing, and related support services. Health sciences include health professions and related sciences, and residency programs. The figure includes only STEM entrants who switched majors to non-STEM fields. The last major field was either the field in which a student was last enrolled in spring 2009 or the field for the last degree attained if the student was not enrolled in spring 2009. Detail may not sum to totals because of rounding. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

Characteristics of STEM Leavers

The two types of STEM leavers (i.e., those who left STEM fields by switching majors and those who left STEM fields by dropping out of college without earning a degree or certificate) exhibited different characteristics. Looking at bachelor's degree STEM entrants first, proportionally more females than males left STEM fields by switching to a non-STEM major (32 percent vs. 26 percent), whereas proportionally more males than females left STEM fields by dropping out of college (24 percent vs. 14 percent) (table 2). Of all racial/ethnic groups, Asians left STEM fields by dropping out of college at the lowest rate (10 percent vs. 20–29 percent for other racial/ethnic groups). Also, proportionally fewer Asians than blacks left STEM fields by switching majors, but there was no measurable difference between Asians and their White and Hispanic counterparts in terms of leaving STEM fields by switching majors. While proportionally more students whose parents had only a high school education or less left STEM fields by dropping out of college than their counterparts whose parents earned a bachelor's or higher degree, no measurable difference by parental education was found in terms of the rate at which students switched major from a STEM to a non-STEM field. Similarly, while proportionally more students in the two lowest quarters of the income level left STEM fields by dropping out of college than their counterparts in the highest quarter of the income level, no measurable difference by income levels was observed in terms of the rate at which students switched major from a STEM to a non-STEM field.

STEM attrition rates also varied by students' precollege academic preparation, as indicated by their high school grade point average (GPA) and the highest level of math course taken in high school. For example, 46 percent of STEM entrants with a high school GPA of less than 2.5 and 41 percent of those who did not take algebra II/trigonometry or higher math courses in high school left STEM fields by dropping out of college, compared with 14 percent of those with a high school GPA of 3.5 or higher and 12 percent of those who took calculus in high school (table 2). In terms of switching majors out of STEM fields, 33 percent of STEM entrants with a high school GPA of between 3.00 and 3.49 did so, compared with 26 percent of those who earned a GPA of 3.5 or higher. About 32–33 percent of STEM entrants who took algebra II/trigonometry or precalculus in high school switched majors, while 24 percent of those who took calculus did so.

Table 2.
Percentage of 2003–04 beginning bachelor's and associate's degree students who entered but subsequently left STEM fields, by demographic, precollege academic, and postsecondary enrollment characteristics: 2003–2009

Demographic, precollege academic, and postsecondary enrollment characteristics	STEM entrants among beginning bachelor's degree students: Left PSE without a degree or certificate[1]	STEM entrants among beginning bachelor's degree students: Switched major to a non-STEM field	STEM entrants among beginning associate's degree students: Left PSE without a degree or certificate[1]	STEM entrants among beginning associate's degree students: Switched major to a non-STEM field
Total	**20.2**	**28.1**	**36.5**	**32.8**
Sex				
Male	23.7	25.5	38.0	28.8
Female	14.2	32.4	32.7	42.6
Race/ethnicity[2]				
White	19.8	28.1	35.8	30.3
Black	29.3	36.0	41.5	36.3
Hispanic	23.1	26.4	39.9	37.6
Asian	9.8	22.6	26.2	28.1
All other races	20.5	25.4	33.4 !	48.9
Highest education of parents				
High school or less	30.1	28.8	35.8	34.2
Some college	22.1	27.2	42.1	31.5
Bachelor's degree or higher	16.6	27.9	31.6	32.8
Income level in 2003–04[3]				
Lowest 25 percent	29.2	28.6	45.9	25.1
Lower middle 25 percent	21.6	28.4	27.9	38.8
Upper middle 25 percent	18.2	27.5	29.6	34.1
Highest 25 percent	15.4	28.0	42.6	34.1
Highest mathematics in high school[4]				
Skipped	46.9	27.1 !	46.6	28.1
None of the following	40.6	17.4 !	47.1	24.3
Algebra II/trigonometry	26.7	32.5	31.0	38.9
Pre-calculus	19.6	32.1	27.3	32.6
Calculus	12.0	23.7	28.7	37.1 !
High school GPA[5]				
Skipped	33.2	26.9	40.5	30.8
Less than 2.50	45.8	25.3 !	41.8	36.3
2.50–2.99	24.6	32.9	37.5	30.4
3.00–3.49	22.1	32.5	36.2	31.3
3.50 or higher	14.1	25.5	21.8	30.8
Selectivity of institution first attended[6]				
Very selective	11.5	26.1	‡	‡
Moderately selective	18.2	30.3	‡	‡
Minimally selective/open admission	38.4	26.4	‡	‡

See notes at end of table.

Table 2.
Percentage of 2003–04 beginning bachelor's and associate's degree students who entered but subsequently left STEM fields, by demographic, precollege academic, and postsecondary enrollment characteristics: 2003–2009—continued

Demographic, precollege academic, and postsecondary enrollment characteristics	STEM entrants among beginning bachelor's degree students		STEM entrants among beginning associate's degree students	
	Left PSE without a degree or certificate[1]	Switched major to a non-STEM field	Left PSE without a degree or certificate[1]	Switched major to a non-STEM field
Level and control of institution first attended				
Public 4-year	19.8	30.5	28.7	39.2
Private nonprofit 4-year	17.5	24.0	‡	‡
For-profit 4-year	56.8	‡	34.3	16.9 !
Public 2-year	‡	‡	36.8	33.9
Private 2-year	‡	‡	39.9	30.5 !
Other	‡	‡	‡	‡
Ever received a Pell Grant through 2009				
No	17.7	27.1	41.2	29.1
Yes	24.6	29.7	31.8	36.5

! Interpret data with caution. Estimate is unstable because the standard error represents more than 30 percent of the estimate.

‡ Reporting standards not met.

[1] "PSE" refers to postsecondary education. "Students who left PSE without a degree or certificate" are also referred to as students who dropped out of college or college dropouts in the text.

[2] Black includes African American, Hispanic includes Latino, and "All other races" includes American Indian, Alaska Native, Native Hawaiian, other Pacific Islanders, and individuals who indicated Two or more races or Other.

[3] The total income in 2002 for independent students or parents of dependent students.

[4] Information for this variable is only available for students under age 24. Those age 24 or above (about 16 percent of the study sample) were included in the "skip" category.

[5] Information for this variable is only available for students under age 24 who received a high school diploma. Those age 24 or above or without a high school diploma (about 21 percent of the study sample) were included in the "skip" category.

[6] The selectivity of institution was developed only for public and private nonprofit 4-year institutions using the following criteria: whether the institution was open admission (had no minimal requirements); the number of applicants; the number of students admitted; the 25th and 75th percentiles of ACT and/or SAT scores; and whether test scores were required for admission. For more information, see Cunningham, A.F. (2006). *Changes in Patterns of Prices and Financial Aid* (NCES 2006-153). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC. In this table, for-profit 4-year institutions and private 2-year and less-than-2-year institutions are included in the category of "minimally selective/open admission."

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

In addition, proportionally more STEM entrants first attending minimally selective/open admission institutions left college without earning a degree (38 percent) than did their peers who first attended highly or moderately selective institutions (12 and 18 percent, respectively). Such differences, however, were not observed when examining the rates at which students switched majors. While STEM entrants first attending public 4-year and private nonprofit 4-year institutions had similar rates of dropping out of college (20 percent and 18 percent, respectively), proportionally more STEM entrants first attending public 4-year institutions switched majors out of STEM fields than those first attending private nonprofit 4-year institutions (30 percent vs. 24 percent). Furthermore, STEM entrants who first attended for-profit 4-year institutions had a higher dropout rate (57 percent) than their counterparts who first attended public 4-year and private nonprofit 4-year institutions (20 percent and 18 percent, respectively).

Finally, the percentage of Pell Grant recipients who dropped out of college was higher than that of non-Pell Grant recipients (25 vs. 18 percent). The difference in the percentage of switching majors between Pell Grant recipients and nonrecipients, however, was not statistically significant (30 percent and 27 percent, respectively).

For associate's degree students, many apparent differences in STEM attrition rates among various groups were in similar directions as those found for bachelor's degree students, but not measurably different due to the smaller sample size of this group. The only measurable differences found were that proportionally more females switched out of STEM fields than males (43 percent vs. 29 percent) and proportionally more students whose high school GPA was lower than 2.5 dropped out of college before earning a degree or certificate (42 percent) than their counterparts whose GPA was 3.5 or higher (22 percent).

STEM Coursetaking and Performance in Postsecondary Education

Students come to college with expectations and preferences based at least in part on their high school coursework, achievement, and parental and social influences. These expectations and preferences are reinforced or altered by students' first-year curricular experiences, which, in turn, influence their decisions about their subsequent coursetaking and major field of study (Attewell, Heil, and Reisel 2012; Crisp, Nora, and Taggart 2009; Huang, Taddese, and Walter 2000; Stinebrickner and Stinebrickner 2011). While this study cannot address this dynamic process, it does provide a close look at the quantity of STEM courses that students take, the level or type of mathematics they take, their success in STEM courses, and the differences in these coursetaking indicators between STEM leavers and persisters. The substantial outflow from STEM fields by the end of the first year has been well documented (Alting and Walser 2007; Chang et al. 2008; Seymour and Hewitt 1997), underscoring the importance of examining first-year data. Hence, this section begins with an examination of STEM coursetaking and performance in the first year and then proceeds to look at corresponding data over the 6 years since students first enrolled in 2003–04. For a detailed classification of STEM courses, see appendix D.

STEM Coursetaking and Performance in the First Year

Participation in Undergraduate STEM Coursework

A majority of bachelor's and associate's degree students attempted to earn STEM credits (87 and 78 percent, respectively), and many did so (81 and 67 percent, respectively) during their first year in college (table 3). On average, STEM credits accounted for 27 percent of all credits earned by bachelor's and associate's degree students in their first year.

Despite this widespread participation, however, there were some measurable differences between STEM leavers and persisters in the number of STEM credits earned in the first year. Regardless of degree level, students who persisted in STEM fields through 2009 earned more STEM credits in the first year than did those who had left STEM fields. Among bachelor's degree students who entered STEM fields in the first year, STEM persisters earned an average of 18 STEM credits, accounting for

Table 3.
Percentage of 2003–04 beginning bachelor's and associate's degree students who attempted STEM credits, percentage who earned STEM credits, average STEM credits earned, and percentage of all credits earned that were STEM credits during the first year of enrollment, by STEM entrance and persistence through 2009

	Beginning bachelor's degree students				Beginning associate's degree students			
STEM entrance and persistence through 2009	Percent who attempted any STEM credits	Percent who earned any STEM credits	Average STEM credits earned[1]	Percent of all credits earned that were STEM credits	Percent who attempted any STEM credits	Percent who earned any STEM credits	Average STEM credits earned[1]	Percent of all credits earned that were STEM credits
Total	**86.9**	**81.5**	**9.1**	**27.2**	**78.3**	**67.1**	**7.8**	**26.8**
Students who entered STEM fields in first year								
STEM leavers, total	93.8	89.5	11.4	40.3	85.5	76.9	9.7	40.4
Left PSE without a degree or certificate[2]	91.4	85.9	11.5	41.4	81.6	70.5	10.0	43.3
Switched major	95.9	92.4	11.4	39.3	89.6	83.9	9.5	37.4
STEM persisters	99.7	99.2	18.3	57.0	98.3	97.3	18.8	58.7
Students who entered STEM fields after first year								
STEM leavers, total	92.7	88.1	9.3	32.0	83.9	73.5	7.9	28.5
Left PSE without a degree or certificate[2]	92.2	82.3	8.7	33.9	81.7	66.7	7.7	28.8
Switched major	93.0	91.6	9.6	30.9	87.0	83.1	8.0	28.2
STEM persisters	96.4	94.8	13.2	43.4	91.8	82.6	11.4	38.7
Students who did not enter STEM field	83.3	76.8	6.9	20.2	75.8	63.7	6.7	23.2
Persisted or completed a degree or certificate	84.9	80.7	7.1	20.6	79.4	70.6	7.1	23.8
Left PSE without a degree or certificate[2]	77.9	62.8	6.0	18.8	71.6	55.6	6.1	22.5

[1] Estimates based only on students who earned STEM credits in the first year.

[2] "PSE" refers to postsecondary education. "Students who left PSE without a degree or certificate" are also referred to as students who dropped out of college or college dropouts in the text.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

57 percent of total credits, in the first year. In comparison, the two types of STEM leavers earned an average of 11 STEM credits, accounting for about 40 percent of total credits, in the first year (table 3). A similar pattern was also found at the associate's degree level: students who entered STEM fields in the first year and persisted in these fields through 2009 earned an average of 19 STEM credits in the first year, compared with about 10 STEM credits earned by the two types of STEM leavers.

Overall, non-STEM entrants were less committed to STEM courses than STEM entrants; proportionally fewer of them enrolled and earned credits in STEM courses during the first year. At the bachelor's degree level, 83 percent of non-STEM entrants took STEM courses and 77 percent earned STEM credits in the first year; the corresponding percentages were 100 and 99 percent for first-year STEM entrants who persisted in STEM fields. About 20 percent of total credits earned by non-STEM entrants in the first year were STEM credits, compared with 57 percent for first-year STEM entrants/persisters. Results followed a similar pattern at the associate's degree level: 76 percent of non-STEM entrants attempted and 64 percent earned STEM credits in the first year, compared with 98 and 97 percent for first-year STEM entrants who persisted in STEM fields. About 23 percent of total credits earned by non-STEM entrants in the first year were STEM credits, lower than the 59 percent for first-year STEM entrants/persisters.

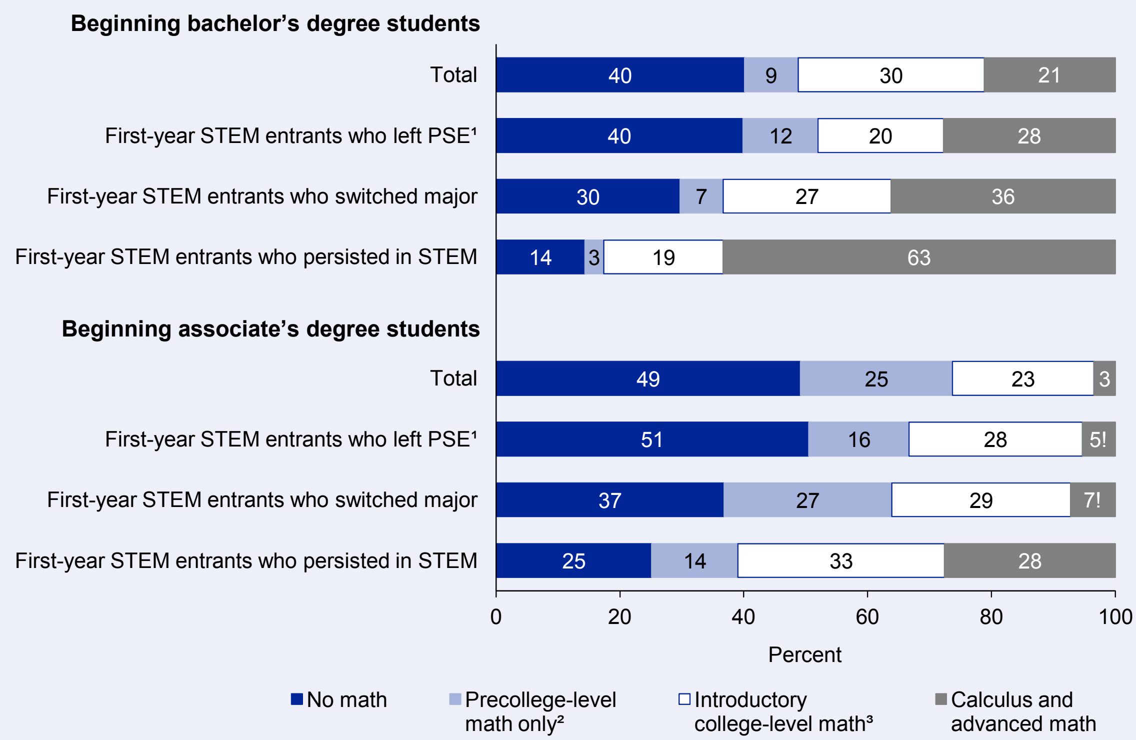
Highest Level of Math Course

Mathematics is a foundation for all STEM disciplines, and thus, deciding whether to take mathematics in the first year and what type of math courses to take is crucial to students' progression along the STEM pipeline (Shaw and Barbuti 2010). During their first year in college, 40 percent of bachelor's degree students did not take mathematics; 9 percent took only precollege-level math courses; 30 percent took introductory college-level but no higher-level mathematics; and 21 percent took calculus or other advanced mathematics (figure 4). Among associate's degree students, about one-half (49 percent) did not take any math courses in the first year. Another quarter concentrated their math coursetaking at the precollege level (25 percent), 23 percent took introductory college math, and 3 percent took calculus or advanced mathematics.

The level of first-year math coursetaking distinguished STEM leavers from STEM persisters. At both the bachelor's and associate's degree levels, proportionally more STEM leavers than STEM persisters did not earn any math credits in their first year, whereas proportionally more STEM persisters than STEM leavers earned credit in calculus or advanced mathematics. For example, among bachelor's degree students, 30–40 percent of those who entered STEM fields in the first year but subsequently left college or switched majors took no mathematics at all in the first year, compared with 14 percent of those who persisted in STEM fields. On the other hand, 63 percent of

STEM persisters, compared with 28–36 percent of the two types of STEM leavers, took calculus or advanced mathematics in the first year. Results followed a similar pattern at the associate's degree level.

Figure 4.
Percentage distribution of the highest level of math course in which 2003–04 beginning bachelor's and associate's degree students earned credits during the first year of enrollment, by STEM entrance and persistence through 2009



! Interpret data with caution. Estimate is unstable because the standard error represents more than 30 percent of the estimate.

[1] "PSE" refers to postsecondary education. "First-year STEM entrants who left PSE" are those who entered STEM fields in 2003−04 and left postsecondary education without earning a degree or certificate as of 2009; these students are also referred to as students who dropped out of college or college dropouts in the text.

[2] Precollege-level math courses are courses designed to provide students with the background and foundation skills necessary to succeed in college-level math courses. Typical precollege-level math courses include arithmetic, beginning or intermediate algebra, plane geometry, and developmental/remedial math. See appendix D for a detailed listing of precollege-level math courses.

[3] Introductory college-level math courses are initial or entry-level college math courses that represent essential prerequisites for students who need to progress to advanced math courses and students whose degrees require an introduction to more rigorous mathematics. These courses are commonly referred to as "gatekeeper" or "gateway" courses. See appendix D for a detailed listing of introductory college-level math courses.

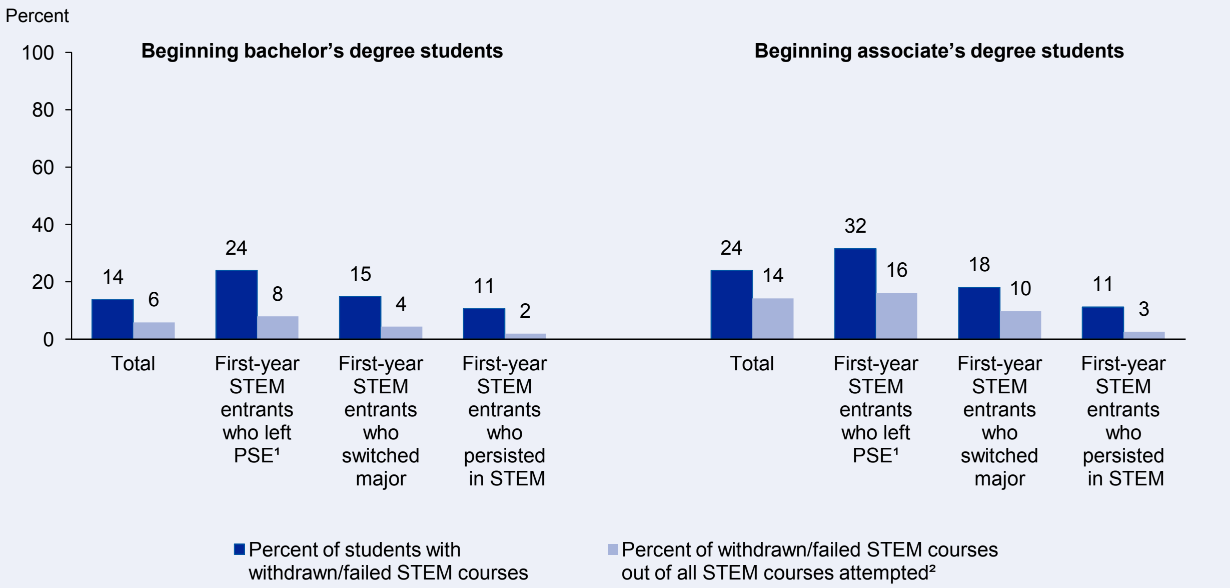
NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Detail may not sum to totals because of rounding. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

Extent of Withdrawn or Failed STEM Courses

The accumulation of few credits may be a consequence of course withdrawals or failures, and excessive STEM course withdrawals/failures may affect students' persistence in STEM fields (Adelman 2006). Figure 5 shows that 14 percent of

Figure 5.
Percentage of 2003–04 beginning bachelor's and associate's degree students who withdrew from or failed to complete any STEM courses, and percentage of withdrawn or failed STEM courses out of all STEM courses attempted during the first year of enrollment, by STEM entrance and persistence through 2009



[1] "PSE" refers to postsecondary education. "First-year STEM entrants who left PSE" are those who entered STEM fields in the first year and left postsecondary education without earning a degree or certificate as of 2009; these students are also referred to as students who dropped out of college or college dropouts in the text.

[2] The percentage of withdrawn or failed STEM courses out of all STEM courses attempted was based on students who attempted STEM credits in the first year.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

bachelor's degree students and 24 percent of associate's degree students withdrew from or failed to complete at least one STEM course during their first year in college.

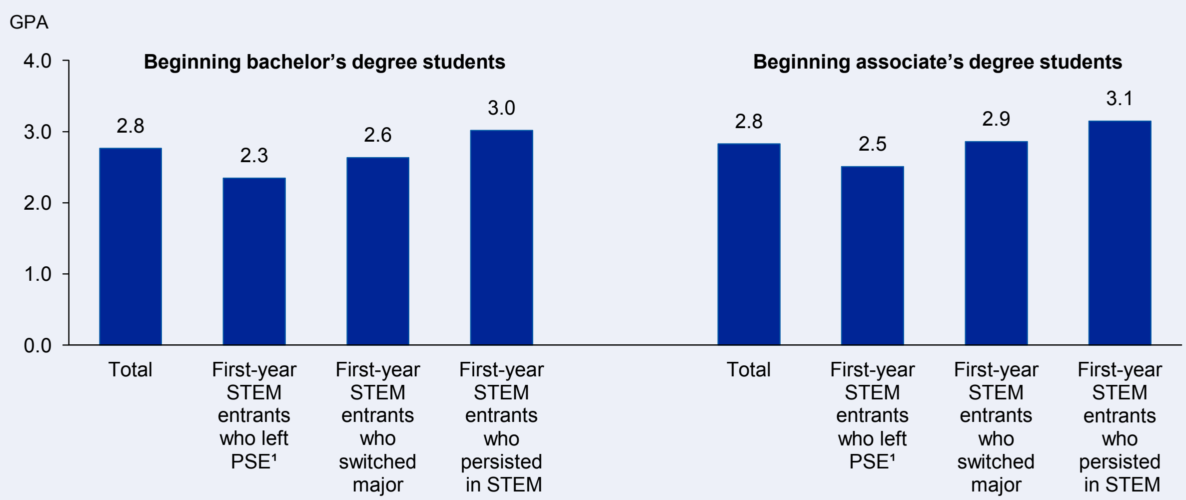
Compared with STEM persisters, STEM leavers had higher levels of withdrawn/failed STEM courses in the first year. Among bachelor's degree students who entered STEM fields in the first year, the percentage of withdrawn/failed STEM courses in all STEM courses attempted in the first year was 8 percent for STEM leavers who dropped out of college, 4 percent for STEM leavers who switched majors, but 2 percent for those who persisted in STEM fields through 2009. Among associate's degree students who entered STEM fields in the first year, the two types of STEM leavers withdrew from or failed to complete about 10–16 percent of STEM courses they attempted in the first year; in contrast, STEM persisters withdrew from or failed to complete just 3 percent of STEM courses.

STEM Performance and Relative Grades

Performance (often measured by students' GPA) may play a role in their decisions to stay in or leave STEM fields. Prior research found that poor grades in STEM courses may push some students out of STEM fields, and better grades in non-STEM than in STEM courses may also draw students into non-STEM fields (Ost 2010; Rask 2010). Therefore, the following section examines students' grades in STEM and non-STEM courses, focusing on whether STEM persisters and leavers differ in their STEM grades in both absolute terms and in the relationship between their STEM and non-STEM grades.

At both the bachelor's and associate's degree levels, STEM leavers tended to earn lower grades in STEM courses during the first year than did their counterparts who persisted in STEM fields through 2009 (figure 6). For example, bachelor's degree students who entered STEM fields in the first year and subsequently dropped out of college or switched majors earned an overall GPA of 2.3 or 2.6, respectively, in their first-year STEM courses, lower than the 3.0 GPA earned by those who stayed in STEM fields through 2009. Similar patterns were also observed at the associate's degree level.

Figure 6.
Grade point average (GPA) earned by 2003–04 beginning bachelor's and associate's degree students in STEM courses during the first year of enrollment, by STEM entrance and persistence through 2009



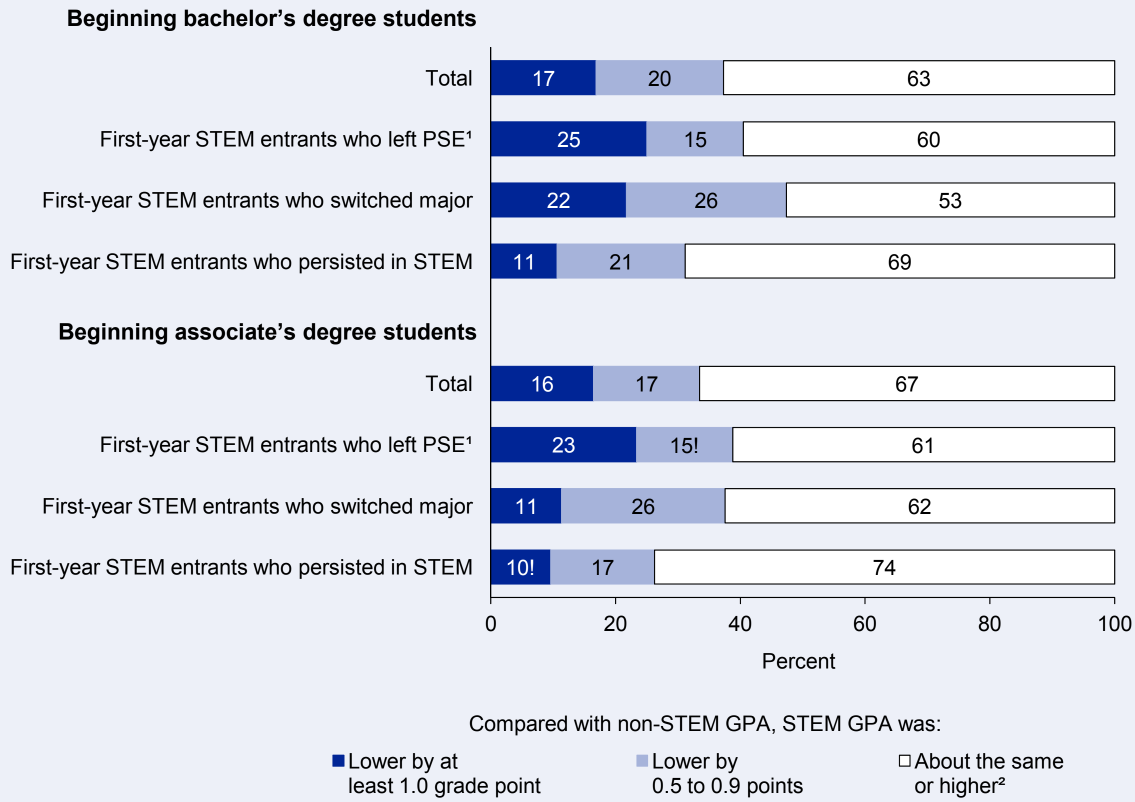
[1] "PSE" refers to postsecondary education. "First-year STEM entrants who left PSE" are those who entered STEM fields in the first year and left postsecondary education without earning a degree or certificate as of 2009; these students are also referred to as students who dropped out of college or college dropouts in the text.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. GPAs are only for the STEM courses in which students earned credits. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

In addition to these group differences in the STEM GPAs, some differences were observed among the groups in the relationship of their STEM performance to their non-STEM performance. Among bachelor's degree students who entered STEM fields in the first year, about one-fourth of STEM leavers (i.e., 25 percent of college dropouts and 22 percent of major switchers) earned STEM grades that were lower than their non-STEM grades by at least one grade point; in contrast, 11 percent of STEM persisters had STEM grades that averaged at least one grade point below their non-STEM GPA (figure 7). Among associate's degree students who entered STEM

Figure 7.
Percentage distribution of 2003–04 beginning bachelor's and associate's degree students by difference between their first-year grade point average (GPA) for STEM and non-STEM courses, by STEM entrance and persistence through 2009



! Interpret data with caution. Estimate is unstable because the standard error represents more than 30 percent of the estimate.

[1] "PSE" refers to postsecondary education. "First-year STEM entrants who left PSE" are those who entered STEM fields in the first year and left postsecondary education without earning a degree or certificate as of 2009; these students are also referred to as students who dropped out of college or college dropouts in the text.

[2] "About the same or higher" means that STEM and non-STEM GPAs are the same or different by less than 0.5 point or STEM GPA is higher than non-STEM GPA by at least 0.5 point.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Comparisons of STEM and non-STEM GPAs are only for students who earned both STEM and non-STEM credits in the first year. Detail may not sum to totals because of rounding. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

fields in the first year, 23 percent of those who dropped out of college, 11 percent of those who switched majors, and 10 percent of STEM persisters earned STEM grades that were lower than their non-STEM grades by at least one grade point, but these percentages were not measurably different from each other.

STEM Coursetaking and Performance Over 6 Years in College

The differences observed in students' first-year STEM coursetaking and performance remained and, in some cases, grew over 6 years of college enrollment from 2003 to 2009. While most students attempted STEM courses during their enrollment between 2003 and 2009,[17] STEM persisters earned far more STEM credits than did STEM leavers.[18] Using bachelor's degree students as an example, STEM persisters, who had already earned more STEM credits than STEM leavers in the first year (as seen in table 3), surpassed their counterparts by an even greater margin over 6 years, earning an average of 81 STEM credits through 2009, compared with 32 STEM credits earned by STEM entrants who departed college without a degree or certificate and 37 STEM credits earned by those who switched majors (figure 8). Overall, 60 percent of the total credits that STEM persisters earned between 2003 and 2009 were in STEM fields. In comparison, STEM credits accounted for 29–39 percent of total credits earned by the two types of STEM leavers.

Although mathematics is an important course for all STEM majors, some STEM entrants did not take any mathematics[19] or took only precollege-level mathematics in college, and these students more frequently were STEM leavers than STEM persisters (figure 9). Among bachelor's degree students who entered STEM fields between 2003 and 2009 and subsequently left college without earning a degree, for example, 21 percent did not take any math courses and 10 percent took only precollege-level math courses during their enrollment. The corresponding percentages for STEM persisters were 2 and 1 percent, respectively. On the other hand, proportionally more STEM persisters took calculus or advanced mathematics than did STEM leavers (81 percent vs. 36 percent of STEM leavers who left college and 57 percent of STEM leavers who switched majors). Similar patterns were observed among associate's

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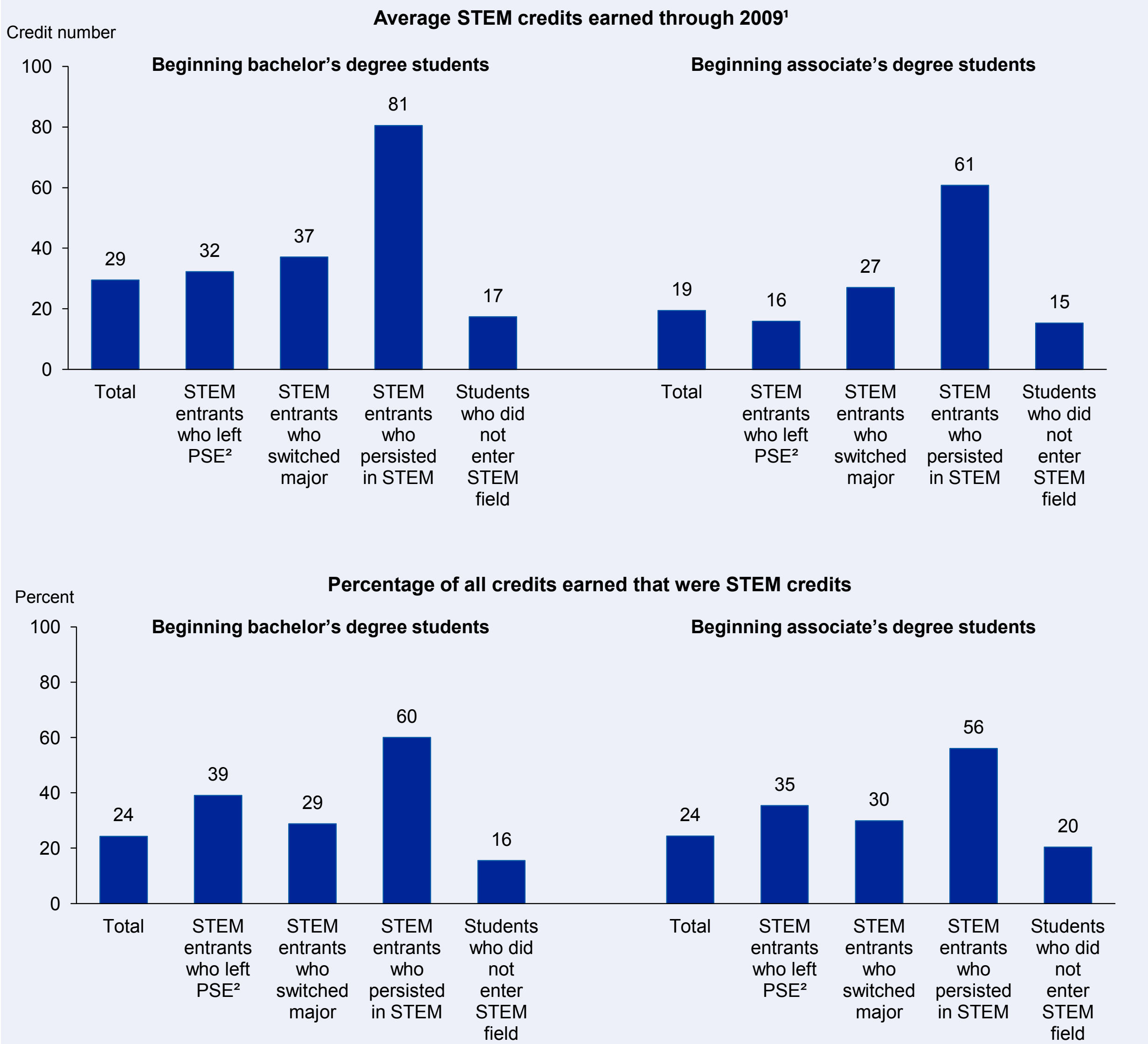
[17] About 97 percent of bachelor's degree students and 90 percent of associate's degree students attempted STEM courses during their enrollment between 2003 and 2009 (Chen and Ho 2012, table 10).
[18] This occurs because STEM persisters, by definition, stay in STEM fields longer than STEM leavers; therefore, they have the opportunity to earn more STEM credits and take more challenging math classes. STEM persisters may also have to fulfill course and graduation requirements for the STEM degree they pursue.
[19] It is possible that some students may have completed Advanced Placement (AP) calculus in high school and were granted a waiver from the postsecondary institution to fulfill the math requirement for graduation.

degree students: 37 percent of STEM entrants who subsequently left college did not take any math courses and 21 percent took only precollege-level math courses during their entire college enrollment; the corresponding percentages for STEM persisters

Figure 8.
Average number of STEM credits earned by 2003–04 beginning bachelor's and associate's degree students during their enrollment through 2009, and of those who earned any credits, percentage of all credits earned that were STEM credits, by STEM entrance and persistence through 2009



[1] Estimates based only on students who earned STEM credit through 2009.

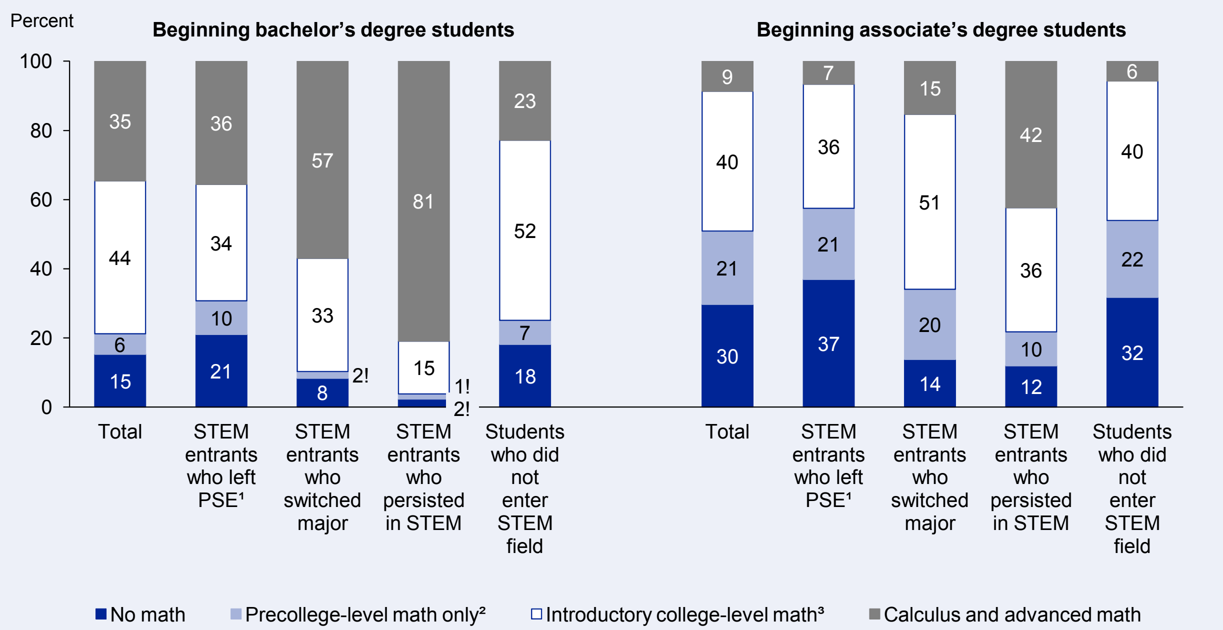
[2] "PSE" refers to postsecondary education. "STEM entrants who left PSE" are those who entered STEM fields between 2003 and 2009 and left postsecondary education without earning a degree or certificate as of 2009; these students are also referred to as students who dropped out of college or college dropouts in the text.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

were 12 percent and 10 percent, respectively. Compared with STEM persisters (42 percent), far fewer STEM leavers took calculus or advanced mathematics (7 percent for college dropouts and 15 percent for those who switched majors).

Figure 9.
Percentage distribution of the highest level of math course in which 2003–04 beginning bachelor's and associate's degree students earned credits during their enrollment through 2009, by STEM entrance and persistence through 2009



! Interpret data with caution. Estimate is unstable because the standard error represents more than 30 percent of the estimate.

[1] "PSE" refers to postsecondary education. "STEM entrants who left PSE" are those who entered STEM fields between 2003 and 2009 and left postsecondary education without earning a degree or certificate as of 2009; these students are also referred to as students who dropped out of college or college dropouts in the text.

[2] Precollege-level math courses are courses designed to provide students with the background and foundation skills necessary to succeed in college-level math courses. Typical precollege-level math courses include arithmetic, beginning or intermediate algebra, plane geometry, and developmental/remedial math. See appendix D for a detailed listing of precollege-level math courses.

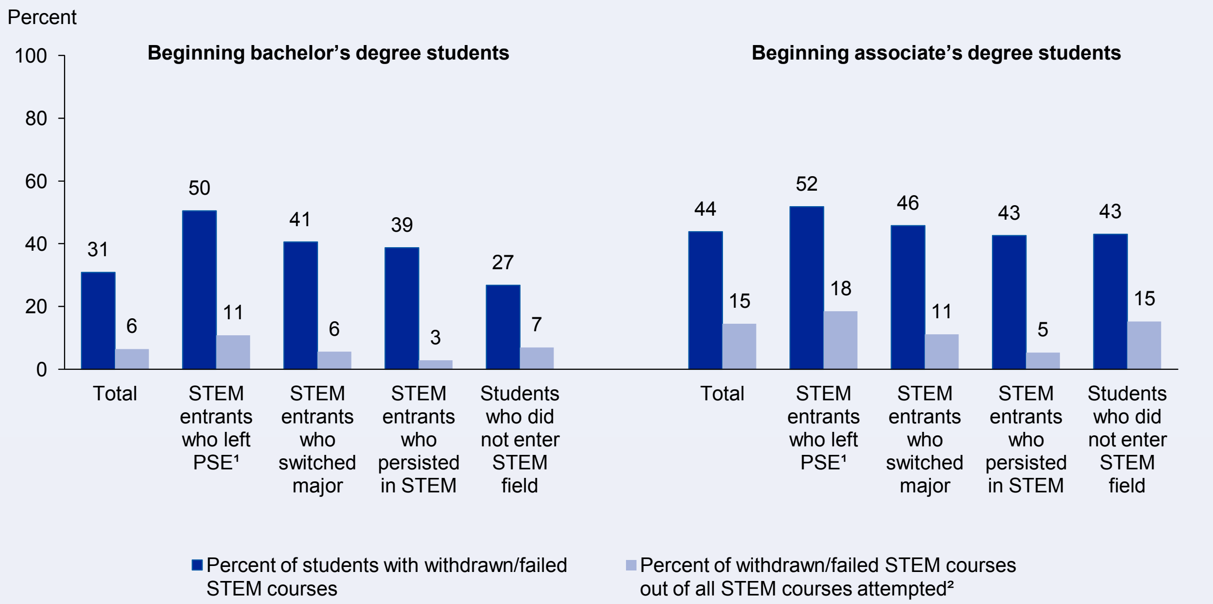
[3] Introductory college-level math courses are initial or entry-level college math courses that represent essential prerequisites for students who need to progress to advanced math courses and students whose degrees require an introduction to more rigorous mathematics. These courses are commonly referred to as "gatekeeper" or "gateway" courses. See appendix D for a detailed listing of introductory college-level math courses.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Detail may not sum to totals because of rounding. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

The volume of withdrawn/failed STEM courses was higher for STEM leavers, especially those who left college without earning a degree, than for STEM persisters (figure 10). At the bachelor's degree level, withdrawn/failed STEM courses accounted for 6–11 percent of all STEM courses attempted by the two types of STEM leavers. The corresponding percentage for STEM persisters was 3 percent, however. At the associate's degree level, withdrawn/failed STEM courses accounted for 11–18 percent of all STEM courses attempted by the two types of STEM leavers, but 5 percent for STEM persisters.

Figure 10.
Percentage of 2003–04 beginning bachelor's and associate's degree students who withdrew from or failed to complete any STEM courses, and percentage of withdrawn or failed STEM courses out of all STEM courses attempted during their enrollment through 2009, by STEM entrance and persistence through 2009



[1] "PSE" refers to postsecondary education. "STEM entrants who left PSE" are those who entered STEM fields between 2003 and 2009 and left postsecondary education without earning a degree or certificate as of 2009; these students are also referred to as students who dropped out of college or college dropouts in the text.

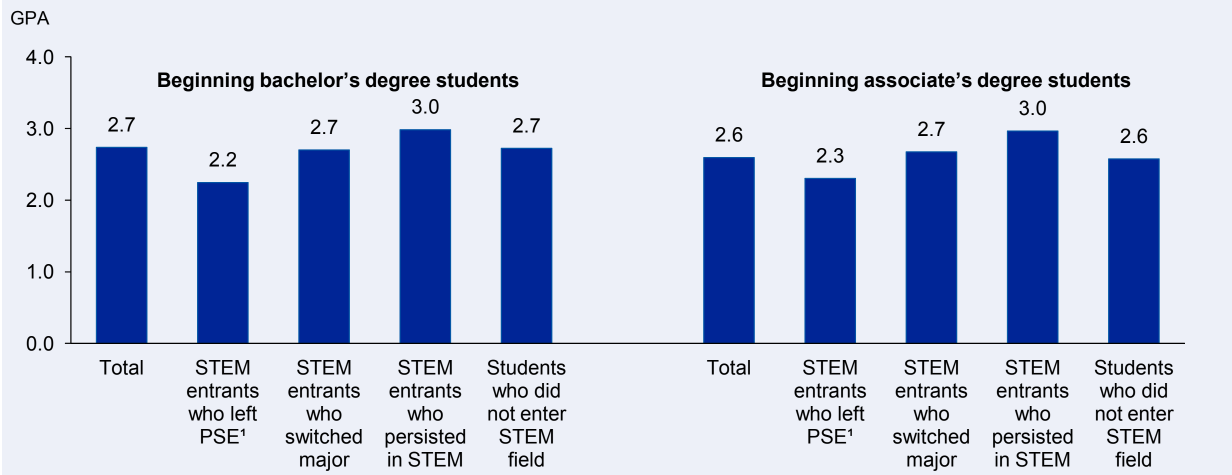
[2] The percentage of withdrawn or failed STEM courses out of all STEM courses attempted was based on students who attempted STEM credits through 2009.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

Findings of STEM performance over 6 years through 2009 were consistent with those in the first year. At both the bachelor's and associate's degree levels, STEM leavers earned lower grades in STEM courses than did STEM persisters (figure 11). In addition, proportionally more STEM leavers than STEM persisters earned lower grades in STEM courses than they did in non-STEM courses (figure 12). Among bachelor's degree students who entered STEM fields from 2003 to 2009, some 20 percent of STEM leavers who dropped out of college and 13 percent of STEM leavers who switched majors had STEM grades that were lower than non-STEM grades by at least one grade point, compared with 4 percent among those who persisted in STEM fields. Similar patterns were found for associate's degree students: 18 percent of STEM leavers who dropped out of college and 7 percent of STEM leavers who switched majors, compared with 3 percent of STEM persisters, earned STEM grades that were lower than non-STEM grades by at least one grade point.

Figure 11.
Grade point average (GPA) earned by 2003–04 beginning bachelor's and associate's degree students in STEM courses during their enrollment through 2009, by STEM entrance and persistence through 2009

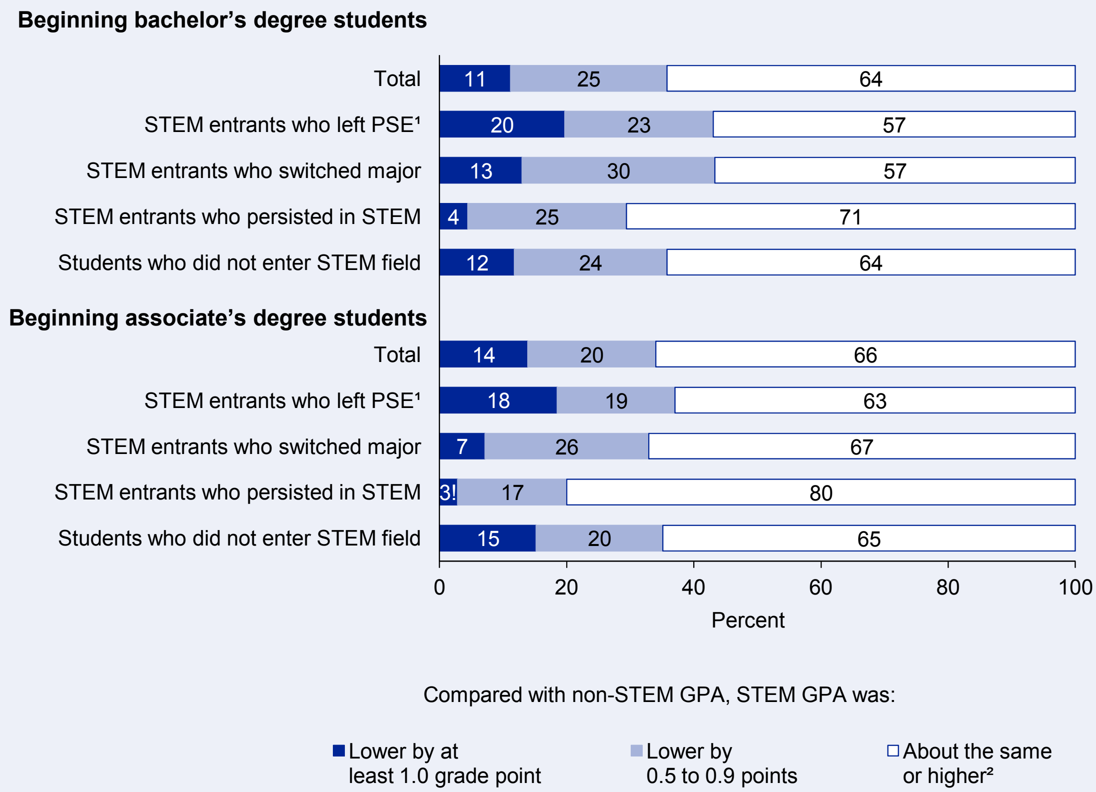


[1] "PSE" refers to postsecondary education. "STEM entrants who left PSE" are those who entered STEM fields between 2003 and 2009 and left postsecondary education without earning a degree or certificate as of 2009; these students are also referred to as students who dropped out of college or college dropouts in the text.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. GPAs are only for the STEM courses in which students earned credits. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

Figure 12.
Percentage distribution of 2003–04 beginning bachelor's and associate's degree students by difference between overall grade point average (GPA) for STEM and non-STEM courses during their enrollment through 2009, by STEM entrance and persistence through 2009



! Interpret data with caution. Estimate is unstable because the standard error represents more than 30 percent of the estimate.

[1] "PSE" refers to postsecondary education. "STEM entrants who left PSE" are those who entered STEM fields between 2003 and 2009 and left postsecondary education without earning a degree or certificate as of 2009; these students are also referred to as students who dropped out of college or college dropouts in the text.

[2] "About the same or higher" means that STEM and non-STEM GPAs are the same or different by less than 0.5 point or STEM GPA is higher than non-STEM GPA by at least 0.5 point.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. Comparisons of STEM and non-STEM GPAs are only for students who earned both STEM and non-STEM credits through 2009. Detail may not sum to totals because of rounding. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico. Standard error tables are available at http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2014001.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

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Factors Associated With STEM Attrition: A Multinomial Probit Analysis

The analyses in the previous sections showed that STEM attrition rates differed across a range of factors from demographic characteristics, family background, and precollege preparation to postsecondary enrollment and STEM coursetaking and performance. These analyses, though informative, did not take into account potentially complex relationships among multiple, often related, factors. For example, the estimates presented in table 2 indicate that proportionally fewer Asian STEM entrants left STEM fields by dropping out of college without earning a degree or certificate than did students from other racial/ethnic groups. This result may be due to the fact that Asian students are often better prepared in high school mathematics than are other students (Berkner and Choy 2008). Such preparation may lead to easier access to selective institutions and higher grades in college (Radford and Horn 2012), two factors that are correlated with STEM attrition in table 2 and figure 11. Given these interrelationships, being Asian may not necessarily be associated with STEM attrition when other factors, such as the selectivity of postsecondary institutions and college-level math coursetaking, are taken into account.

The following section describes the results of a multivariate analysis that introduces multiple factors simultaneously and allows for examination of how each factor is associated with STEM attrition, net of the others. In contrast to some multivariate analyses which seek to identify causal relationships, this analysis is not designed to determine the cause of STEM attrition, but rather to refine the preceding bivariate analyses by analyzing the relative strength of associations among various factors and STEM attrition, while taking into account the interactions of multiple factors.

Model Specifications

After entering a STEM field, students' possible STEM outcomes can be defined in three ways: they can persist and eventually earn a degree in a STEM field, they can switch majors and pursue a non-STEM field (whether or not they complete), or they can quit school entirely without earning a degree or certificate. In order to examine the simultaneous association of these multiple discrete outcomes with other related factors, a multinomial probit (MNP) model was used. MNP is one of the statistical techniques commonly used to predict the probability of one event occurring (such as switching majors) over several mutually exclusive alternatives (Borooah 2001; Koop

2008). The results are often presented as average marginal effects, which measure the change in the probability of observing an outcome when an independent variable changes by one unit while keeping all other variables constant in the model (Liao 1994). The following MNP analysis focuses on the two types of STEM attrition (i.e., switching majors and leaving college without a degree or certificate). Only STEM entrants were selected for this analysis.[20] The model was run separately for bachelor's and associate's degree students, and the MNP results are reported separately for each level.

Many factors have been identified in the literature as potentially important to STEM attrition. These factors include (but are not limited to) demographic characteristics, precollege academic preparation, institutional context, climate and support, and coursetaking and performance. The MNP model below attempted to include as many of these factors (i.e., independent variables) as available in BPS:04/09 to examine their net associations with STEM outcomes while controlling for the interrelationships among these factors. Specifically, the MNP model included sex, race/ethnicity, parental education, and income as demographic factors. The STEM literature has reported that women, underrepresented minorities, first-generation students, and those from low-income backgrounds tend to have higher STEM attrition rates than their counterparts (Anderson and Kim 2006; Griffith 2010; Hill, Corbett, and Rose 2010; Huang, Taddese, and Walter 2000; Kokkelenberg and Sinha 2010; Shaw and Barbuti 2010). These demographic characteristics also influence many aspects of college experiences, which, in turn, are associated with STEM outcomes (Berkner and Choy 2008; Chen 2009; Seymour and Hewitt 1997; Skomsvold, Radford, and Berkner 2011).

For precollege academic preparation, two high school variables were included in the MNP model: GPA and the highest level of math course taken.[21] While high school GPA measures students' overall academic preparation for college, the kind of math courses taken indicates the level of math preparation students achieved in high school and is directly related to majoring and persisting in STEM fields (Haag and Collofello 2008; Huang, Taddese, and Walter 2000; Kokkelenberg and Sinha 2010).

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[20] A similar MNP model was also run for non-STEM entrants, and the results are presented in table B-2 in appendix B.

[21] Information on high school coursetaking in mathematics was not collected for students age 24 or above (about 16 percent of the study sample). Information on high school GPA was not collected for students age 24 or above or those who had not received a high school diploma (about 21 percent of the study sample). To avoid excluding these students from the MNP analysis, missing cases for these two variables were retained in the "skip" category. Consequently, the MNP estimates for these two variables may not be as accurate as they would be if these variables were available for all students.

Although institutional climate, support, and resources for STEM learning and faculty characteristics have also been identified as potential factors associated with STEM attrition (Blickenstaff 2005; Chang et al. 2011; Daempfle 2003; Eagan et al. 2011b; Espinosa 2011; Fouad et al. 2010; Ost 2010; Price 2010; Seymour 2001; Thompson et al. 2007), none of these variables are available in BPS:04/09. Instead, this study used the level and control of the institution students first attended and the selectivity of the initial 4-year institution as proxies for institution contextual factors for STEM learning.

Finally, the amount of STEM coursework in college (especially in the first year), the type of STEM courses taken (particularly in mathematics), and how well students perform (especially performance in STEM fields relative to the performance in non-STEM fields) are figured prominently in students' decisions to leave STEM fields (Bettinger 2010; Ost 2010; Rask 2010; Seymour 2001; Seymour and Hewitt 1997; Stinebrickner and Stinebrickner 2011). These experiences were represented by the following variables in the MNP model: percentage of STEM credits among all credits earned in the first year, the highest math course taken in the first year of college, percentage of withdrawn/failed STEM courses in all STEM courses attempted through 2009, STEM GPA compared with non-STEM GPA in the first year and through 2009, and overall GPA through 2009.[22]

Factors Associated With STEM Attrition

Table 4 presents the results for the two types of STEM attrition among beginning bachelor's degree students—changing majors and leaving postsecondary education—compared with the base category, "persisting in STEM fields." The comparison groups are denoted by italics; for example, White students comprise the comparison group for race/ethnicity, which is referenced when discussing the results for students in other racial/ethnic groups.

[22] To avoid multicollinearity problems, variables that had high correlations with other variables in the model were excluded from the MNP analysis. For example, the percentage of withdrawn/failed STEM courses out of all STEM courses attempted in the first year was not included because it had a high correlation with the percentage of withdrawn/failed STEM courses out of all STEM courses attempted through 2009 (e.g., 0.69 among beginning associate's STEM entrants). Multicollinearity may increase the standard errors of the regression coefficients for those highly correlated variables; consequently, significant coefficients may become nonsignificant or the sign of coefficients may change (Cohen and Cohen 1983).

Table 4.
Average marginal effects of various characteristics on the probability of students leaving STEM fields among 2003−04 beginning bachelor's students who entered STEM fields between 2003 and 2009, and the average predicted probability of leaving STEM fields among various groups of STEM entrants

Characteristics	Switched major to a non-STEM field		Left PSE without a degree or certificate[1]	
	Average marginal effect[2]	Average predicted probability[3]	Average marginal effect[2]	Average predicted probability[3]
Demographic characteristics				
Sex				
Female	0.02	27.7	-0.05	14.9 **
Male	†	*26.0*	†	*19.8*
Race/ethnicity[4]				
Black	-0.03	34.7	-0.03	16.8
Hispanic	-0.05	22.3	-0.05	14.4
Asian	-0.06	24.5	-0.06	13.5
All other races	-0.03	23.9	0.00	19.7
White	†	*26.5*	†	*19.7*
Highest education of parents				
High school or less	-0.02	25.8	0.00	18.6
Some college	-0.03	24.2	-0.01	17.5
Bachelor's degree or higher	†	27.4	†	18.4
Income level in 2003−04[5]				
Lowest 25 percent	0.00	27.1	0.08	25.2 *
Lower middle 25 percent	0.00	27.3	0.02	18.9
Upper middle 25 percent	-0.02	25.1	-0.02	14.5
Highest 25 percent	†	*27.2*	†	*16.7*
Precollege academic preparation				
Highest mathematics in high school[6]				
Skipped	-0.05	19.9	0.05	23.4
None of the following	-0.15	10.6 *	0.01	19.3
Algebra II/trigonometry	0.04	29.1	0.00	17.7
Pre-calculus	0.04	29.1	0.00	17.9
Calculus	†	*25.2*	†	*18.2*
High school GPA[7]				
Skipped	0.07	31.4	0.02	21.8
Less than 2.50	-0.08	16.9	0.03	22.7
2.50–2.99	0.05	30.0	-0.08	11.7 **
3.00–3.49	0.04	28.8	-0.03	16.8
3.50 or higher	†	*24.8*	†	*19.3*
Type of institution first attended				
Selectivity of 4-year institution first attended[8]				
Minimally selective/open admission	-0.05	25.1	0.15	30.2 ***
Moderately selective	-0.04	25.7	0.01	15.5
Very selective	†	*29.7*	†	*14.7*
Level and control of institution first attended				
Private nonprofit 4-year	-0.09	21.3 ***	0.03	19.8
For-profit 4-year	-0.22	7.9 ***	0.15	32.0
Public 4-year	†	*29.9*	†	*16.8*

See notes at end of table.

Table 4.
Average marginal effects of various characteristics on the probability of students leaving STEM fields among 2003−04 beginning bachelor's students who entered STEM fields between 2003 and 2009, and the average predicted probability of leaving STEM fields among various groups of STEM entrants—continued

Characteristics	Switched major to a non-STEM field: Average marginal effect[2]	Switched major to a non-STEM field: Average predicted probability[3]	Left PSE without a degree or certificate[1]: Average marginal effect[2]	Left PSE without a degree or certificate[1]: Average predicted probability[3]
First-year STEM coursetaking and performance				
Percent of STEM credits in all credits earned in first year				
Lower than 25 percent	0.21	39.3 ***	0.02	19.9
25−49 percent	0.14	32.3 ***	0.01	18.4
50 percent or higher	†	*17.9*	†	*17.8*
Highest mathematics in first year[9]				
No math	0.04	27.4	0.04	21.2
Precollege-level math	0.08	31.3	0.02	19.9
Introductory math	0.08	30.9 *	-0.01	16.3
Calculus/advanced math	†	*23.3*	†	*17.7*
STEM GPA compared to non-STEM GPA in first year				
Lower by at least 1.0 grade point	0.08	32.3	0.00	19.0
Lower by 0.5 to 0.9 grade point	0.05	29.1	-0.02	16.7
About the same or higher[10]	†	*24.3*	†	*18.7*
STEM and overall performance through 2009				
Percent of withdrawn/failed STEM courses out of all STEM courses attempted through 2009				
10 percent or higher	0.09	34.3 *	0.11	26.9 **
Less than 10 percent	†	*25.4*	†	*15.8*
STEM GPA compared to non-STEM GPA through 2009				
Lower by at least 1.0 grade point	0.09	33.6	0.07	25.5
Lower by 0.5 to 0.9 grade points	0.06	30.6 *	-0.02	15.7
About the same or higher[10]	†	*24.2*	†	*18.2*
Overall GPA through 2009				
Less than 2.50	-0.18	16.9 ***	0.27	35.9 ***
2.50–2.99	-0.09	25.3 *	0.08	17.1 **
3.00–3.49	-0.03	31.7	0.02	11.1
3.50 or higher	†	*34.6*	†	*8.7*

See notes at end of table.

Table 4.
Average marginal effects of various characteristics on the probability of students leaving STEM fields among 2003−04 beginning bachelor's students who entered STEM fields between 2003 and 2009, and the average predicted probability of leaving STEM fields among various groups of STEM entrants—continued

p* < .05, ** *p* < .01, * *p* < .001.

† Not applicable for the comparison group.

[1] "PSE" refers to postsecondary education. "Students who left PSE without a degree or certificate" are also referred to as students who dropped out of college or college dropouts in the text.

[2] Marginal effect measures the average percentage point change in the predicted probability of having a STEM attrition outcome associated with a one unit change in an independent variable, after controlling for the covariation of the variables in the model.

[3] Average probability of having a STEM attrition outcome after controlling for the covariation of the variables in the model.

[4] Black includes African American; Hispanic includes Latino; and "All other races" includes American Indian, Alaska Native, Native Hawaiian, other Pacific Islanders, and individuals who indicated Two or more races or Other.

[5] Total income in 2002 for independent students or parents of dependent students.

[6] Information for this variable Is only available for students under age 24. Those age 24 or above (about 16 percent of the study sample) were included in the "skip" category.

[7] Information for this variable is only available for students under age 24 who received a high school diploma. Those age 24 or above or without a high school diploma (about 21 percent of the study sample) were included in the "skip" category.

[8] The selectivity of institution was developed only for public and private nonprofit 4-year institutions using the following criteria: whether the institution was open admission (no minimal requirements); the number of applicants; the number of students admitted; the 25th and 75th percentiles of ACT and/or SAT scores; and whether or not test scores were required. For more information, see Cunningham, A.F. (2006). *Changes in Patterns of Prices and Financial Aid* (NCES 2006-153). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC. In this table, for-profit 4-year institutions are included in the category of "minimally selective/open admission."

[9] Precollege-level math courses are courses designed to provide students with the background and foundation skills necessary to succeed in college-level math courses. Typical precollege level math courses include arithmetic, beginning or intermediate algebra, plane geometry, and developmental/remedial math. Introductory math courses are initial or entry-level college math courses that represent essential prerequisites for students who need to progress to advanced math courses and students whose degrees require an introduction to more rigorous mathematics. These courses are commonly referred to as "gatekeeper" or "gateway" courses. See appendix D for a detailed listing of math courses in each level.

[10] "About the same or higher" means that STEM and non-STEM GPAs are the same or different by less than 0.5 point or STEM GPA is higher than non-STEM GPA by at least 0.5 point.

NOTE: F-test for the overall MNP model for STEM entrants among beginning bachelor's degree students is 7.89 (p<0.001). STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. The table includes beginning bachelor's and associate's degree students who entered STEM fields between 2003 and 2009. The italicized category in each variable is the comparison group. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09), and Postsecondary Education Transcript Study of 2009 (PETS:2009).

To determine whether a given independent variable was associated with a statistically significant change in students' predicted probability of STEM attrition, two analyses were performed. First, MNP was used to identify variables that demonstrated a statistically significant association with the likelihood of attrition. Then, for each statistically significant association identified by MNP, the average marginal effect (AME) of the variable on the predicted probability of STEM attrition was calculated. The AME represents the average percentage point change in the predicted probability of STEM attrition associated with a one unit change in an independent variable, net of other variables in the model. To provide an easier interpretation of the results, the table also presents the average predicted probability (APP) of leaving STEM fields for each group of students. APP represents the adjusted probability after controlling for the covariation among all the independent variables listed in the table.

A significant AME (indicated by an asterisk) suggests that the observed change in the predicted probability is significantly different from zero. For example, the MNP model for bachelor's degree students shows that the AME of being female on college departure was significant with a value of "-0.05." This means that female STEM entrants had a lower probability of leaving college without a degree or certificate than their male counterparts, or more specifically, the average predicted probability of dropping out of college for female STEM entrants (i.e., 15 percent) was 5 percentage points lower than that for male students (i.e., 20 percent) while keeping all other variables in the model constant.

Beginning Bachelor's Degree Students

The F-test of the overall MNP model for STEM entrants among bachelor's degree students was significant ($F=7.89$, $p < 0.001$), indicating that one or more independent variables included in the model were associated with one or both types of STEM attrition above what would be expected by chance (table 4).

Leaving STEM Fields by Switching Majors. The amount of STEM coursetaking in the first year, the type of math courses taken in the first year, and performance in STEM coursework were among the most important factors associated with the outcome of leaving STEM fields by switching majors. Specifically, STEM entrants with lower STEM credit loads in the first year (i.e., less than 25 percent of total credits earned in STEM fields) experienced a higher probability of switching majors than those with larger STEM credit loads in the first year (i.e., 50 percent or more of total credits earned in STEM fields) (39 percent vs. 18 percent). Compared with students who took calculus or advanced math courses in the first year of college, those who took introductory math courses had a higher probability of switching majors (31 percent vs. 23 percent). The level of withdrawn/failed STEM courses was another significant factor: STEM entrants who withdrew or failed at least 10 percent of their STEM courses during their college enrollment (as opposed to less than 10 percent) had a higher probability of switching to non-STEM majors (34 percent vs. 25 percent). The probability of switching majors was also higher among students whose STEM grades were lower than their non-STEM grades (by 0.5 to 0.9 points), compared with those whose STEM grades were equal to or higher than their non-STEM grades (31 percent vs. 24 percent).

Unlike the results of the bivariate analysis, none of the demographic characteristics were significantly associated with switching from a STEM to non-STEM major. More specifically, being female or being Asian—two significant factors related to switching majors in the bivariate analysis—were no longer significant after controlling for other factors in the MNP analysis. The type of first institution, however, continued to be significant: STEM entrants who first attended public

4-year institutions had a higher probability of switching majors than their counterparts who first attended private nonprofit 4-year institutions (30 percent vs. 21 percent) and for-profit 4-year institutions (30 percent vs. 8 percent), even after controlling for demographic characteristics, precollege academic preparation, and STEM coursetaking and performance,

Students' overall college GPA was negatively associated with switching majors after controlling for other factors in the model. The probability of switching majors was higher among STEM entrants with an overall college GPA of 3.5 or higher (35 percent) than among those who earned a GPA of less than 3.0 (17–25 percent). Further, those who took calculus in high school also appeared to have a higher probability of switching majors than those who took no mathematics beyond algebra II or trigonometry in high school (25 percent vs. 11 percent). These seemingly counterintuitive patterns suggest that all other factors being equal, high-performing students or academically strong students may be more prone to leave STEM fields by switching majors than low-performing or academically weak students, who were more likely to leave STEM fields by leaving college, as shown below.

Leaving College Without Earning a Degree or Certificate. Several groups of STEM entrants had a higher probability of exiting STEM fields by leaving college all together without earning a degree or certificate. Compared with their counterparts, STEM entrants who were male, from low-income backgrounds, and who first attended the least selective institutions had a higher probability of leaving STEM fields by dropping out of college. Low college performance as well as poor progress in STEM coursework also appeared to be important factors: earning an overall GPA of less than 3.0 (versus a GPA of 3.5 or higher) and withdrawing from or failing at least 10 percent of STEM courses attempted through 2009 (vs. less than 10 percent) were associated with an increased probability of leaving STEM fields by exiting college without earning a degree or certification.[23]

Beginning Associate's Degree Students

Leaving STEM Fields by Switching Majors. The F-test of the overall MNP model for STEM entrants among associate's degree students was significant (F=6.07, $p < 0.001$), again indicating that one or more independent variables included in the model were associated with one or both types of STEM attrition above what would be expected by chance (table 5).

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[23] Several factors (i.e., income, selectivity of the first institution, and overall GPA) were also significantly associated with the probability of leaving college without earning a degree or certificate among non-STEM entrants (appendix table B-2), suggesting that these are common factors associated with dropping out of college for all students.

Table 5.
Average marginal effects of various characteristics on the probability of students leaving STEM fields among 2003−04 beginning associate's students who entered STEM fields between 2003 and 2009, and the average predicted probability of leaving STEM fields among various groups of STEM entrants

Characteristics	Switched major to a non-STEM field: Average marginal effect[2]	Switched major to a non-STEM field: Average predicted probability[3]	Left PSE without a degree or certificate[1]: Average marginal effect[2]	Left PSE without a degree or certificate[1]: Average predicted probability[3]
Demographic characteristics				
Sex				
Female	0.16	42.8 **	-0.07	28.9
Male	†	*27.1*	†	*36.1*
Race/ethnicity[4]				
Black	0.06	34.3	-0.08	26.7
Hispanic	0.10	37.9	0.03	37.6
Asian	0.06	33.7	0.01	36.0
All other races	0.25	52.9 **	-0.08	26.5
White	†	*28.2*	†	*34.9*
Highest education of parents				
High school or less	0.04	33.6	-0.01	31.8
Some college	0.01	31.4	0.04	37.6
Bachelor's degree or higher	†	*30.0*	†	*33.1*
Income level in 2003−04[5]				
Lowest 25 percent	-0.20	19.3 **	0.12	45.1
Lower middle 25 percent	-0.03	36.2	-0.03	29.9
Upper middle 25 percent	-0.02	37.5	-0.08	25.7
Highest 25 percent	†	*39.0*	†	*33.3*
Precollege academic preparation				
Highest mathematics in high school[6]				
Skipped	-0.23	16.8 *	0.24	57.2 *
None of the following	-0.12	27.7	0.00	33.6
Algebra II/trigonometry	-0.01	38.3	-0.07	26.5
Pre-calculus	-0.04	35.8	-0.06	27.6
Calculus	†	*39.5*	†	*33.7*
High school GPA[7]				
Skipped	0.18	42.3 *	-0.11	26.2 *
Less than 2.50	0.13	37.3 *	0.01	38.0
2.50–2.99	0.05	29.5	-0.01	35.4
3.00–3.49	0.01	25.3	0.02	38.4
3.50 or higher	†	*24.3*	†	*36.7*
Type of institution first attended				
Level and control of institution first attended				
Private 2-year	-0.04	29.1	0.03	36.5
Other[8]	-0.08	25.2	0.02	35.1
Public 2-year	†	*33.4*	†	*33.4*
First-year STEM coursetaking and performance				
Percent of STEM credits in all credits earned in first year				
Lower than 25 percent	0.16	42.8 **	-0.05	30.1
25−49 percent	0.05	31.5	0.01	35.9
50 percent or higher	†	*26.8*	†	*34.7*

See notes at end of table.

Table 5.
Average marginal effects of various characteristics on the probability of students leaving STEM fields among 2003–04 beginning associate's students who entered STEM fields between 2003 and 2009, and the average predicted probability of leaving STEM fields among various groups of STEM entrants—continued

Characteristics	Switched major to a non-STEM field		Left PSE without a degree or certificate[1]	
	Average marginal effect[2]	Average predicted probability[3]	Average marginal effect[2]	Average predicted probability[3]
Highest mathematics in first year[9]				
No math	0.11	30.5	0.04	31.0
Precollege-level math	0.17	35.7 *	0.10	37.0
Introductory math	0.16	34.9 *	0.09	36.2
Calculus/advanced math	†	*19.2*	†	*27.2*
STEM GPA compared to non-STEM GPA in first year				
Lower by at least 1.0 grade point	0.02	32.2	0.01	35.3
Lower by 0.5 to 0.9 grade point	0.06	36.8	-0.05	29.5
About the same or higher[10]	†	*30.5*	†	*34.7*
STEM and overall performance through 2009				
Percent of withdrawn/failed STEM courses out of all STEM courses attempted through 2009				
10 percent or higher	0.04	35.4	0.11	41.3 **
Less than 10 percent	†	*30.9*	†	*30.7*
STEM GPA compared to non-STEM GPA through 2009				
Lower by at least 1.0 grade point	0.06	35.5	0.20	53.0 *
Lower by 0.5 to 0.9 grade points	0.09	38.9 *	-0.05	28.3
About the same or higher[10]	†	*29.8*	†	*33.2*
Overall GPA through 2009				
Less than 2.50	-0.20	18.5 **	0.40	60.7 ***
2.50–2.99	-0.04	35.0	0.07	27.6
3.00–3.49	0.06	45.1	0.06	14.4
3.50 or higher	†	*38.7*	†	*20.3*

See notes at end of table.

Table 5.
Average marginal effects of various characteristics on the probability of students leaving STEM fields among 2003–04 beginning associate's students who entered STEM fields between 2003 and 2009, and the average predicted probability of leaving STEM fields among various groups of STEM entrants—continued

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$.

† Not applicable for the comparison group.

[1] "PSE" refers to postsecondary education. "Students who left PSE without a degree or certificate" are also referred to as students who dropped out of college or college dropouts in the text.

[2] Marginal effect measures the average percentage point change in the predicted probability of having a STEM attrition outcome associated with a one unit change in an independent variable, after controlling for the covariation of the variables in the model.

[3] Average probability of having a STEM attrition outcome after controlling for the covariation of the variables in the model.

[4] Black includes African American, Hispanic includes Latino, and "All other races" includes American Indian, Alaska Native, Native Hawaiian, other Pacific Islanders, and individuals who indicated Two or more races or Other.

[5] Total income in 2002 for independent students or parents of dependent students.

[6] Information for this variable Is only available for students under age 24. Those age 24 or above (about 16 percent of the study sample) were included in the "skip" category.

[7] Information for this variable is only available for students under age 24 who received a high school diploma. Those age 24 or above or without a high school diploma (about 21 percent of the study sample) were included in the "skip" category.

[8] Includes all 4-year and less-than-2-year institutions.

[9] Precollege-level math courses are courses designed to provide students with the background and foundation skills necessary to succeed in college-level math courses. Typical precollege level math courses include arithmetic, beginning or intermediate algebra, plane geometry, and developmental/remedial math. Introductory math courses are initial or entry-level college math courses that represent essential prerequisites for students who need to progress to advanced math courses and students whose degrees require an introduction to more rigorous mathematics. These courses are commonly referred to as "gatekeeper" or "gateway" courses. See appendix D for a detailed listing of math courses in each level.

[10] "About the same or higher" means that STEM and non-STEM GPAs are the same or different by less than 0.5 point or STEM GPA is higher than non-STEM GPA by at least 0.5 point.

NOTE: F-test for the overall MNP model for STEM entrants among beginning associate's degree students is 6.07 (p<0.001). STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. The table includes beginning bachelor's and associate's degree students who entered STEM fields between 2003 and 2009. The italicized category in each variable is the comparison group. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09), and Postsecondary Education Transcript Study of 2009 (PETS:2009).

The main findings for associate's degree students were largely similar to those for bachelor's degree students; that is, among all factors included in the model, the amount of STEM coursetaking in the first year, the type of math courses taken in the first year, and performance in STEM courses were among the most important factors. Specifically, STEM entrants who had lower STEM credit loads in the first year, took precollege-level or introductory math courses in the first year, earned STEM grades that were lower than non-STEM grades (by 0.5 to 0.9 points) had a higher probability of switching majors than their counterparts who had higher STEM credits loads in the first year (43 percent vs. 27 percent), took advanced math courses in the first year (35–36 percent vs. 19 percent), and whose STEM grades were equal to or higher than their non-STEM grades (39 percent vs. 30 percent).

While the bivariate analysis found that females switched from STEM to non-STEM majors more frequently than males at both the bachelor's and associate's degree levels (as seen in table 2), this finding held only for associate's degree students in the multivariate analysis: after controlling for the other variables in the model, female

STEM entrants had a higher probability of switching majors (16 percentage points higher) than their male counterparts, with the average predicted probability of 43 percent for females compared with that of 27 percent for males. Income was another significant factor for associate's degree students: STEM entrants from low-income backgrounds had a lower probability of leaving STEM fields by switching majors (19 percent) than their counterparts from high-income backgrounds (39 percent).

Students' overall college GPA followed a similar pattern seen for bachelor's degree students; their college GPA was negatively associated with switching majors after controlling for other factors in the model. The probability of leaving STEM fields by switching majors was 39 percent for STEM entrants with an overall college GPA of 3.5 or higher and 19 percent for those with an overall GPA of less than 2.5. However, the relationship was reversed when looking at high school GPA: those who earned a high school GPA of less than 2.5 had a higher probability of switching majors than their counterparts with a high school GPA of 3.5 or higher (37 percent vs. 24 percent).

It should be noted that the direction of the negative association between college GPA and switching majors is not known. The analysis could not determine whether students with higher college GPAs were more prone to switch majors or whether their higher GPA was a result of switching to a non-STEM field in which earning high grades may be relatively easier than in STEM fields.[24]

Leaving College Without Earning a Degree or Certificate. Only performance measures (overall and in STEM fields) emerged as significant factors associated with exiting STEM fields by leaving college altogether at the associate's degree level: STEM entrants who earned an overall college GPA of less than 2.5 (vs. a GPA of 3.5 or higher), who earned a GPA in STEM courses that was at least one grade point below their non-STEM GPA (vs. a STEM GPA that was similar to or higher than their non-STEM GPA), or who had withdrawn or failed to complete at least 10 percent of STEM courses during their college career (as opposed to less than 10 percent) experienced an increased probability of leaving STEM fields via college departure.

[24] Kokkelenberg and Sinha (2010) found that STEM departments usually had harder grading scales than many non-STEM departments.

Summary

Rising concern about America's ability to maintain its competitive position in the global economy has prompted calls for the U.S. higher education system to produce more graduates with training and expertise in STEM fields (President's Council of Advisors on Science and Technology 2012). To attain this goal, policymakers recommend reducing STEM attrition in college, arguing that retaining more students in STEM fields in college is one way to expand the pool of STEM professionals that the nation needs to advance economically and be globally competitive. Within this context, this study presents an examination of students' attrition from STEM fields over 6 years in college using data from the 2004/09 Beginning Postsecondary Students Longitudinal Study (BPS:04/09) and the associated 2009 Postsecondary Education Transcript Study (PETS:09).

Based on students' reported major fields at the three points in time (2004, 2006, and 2009) when BPS:04/09 data were collected, 28 percent of bachelor's degree students and 20 percent of associate's degree students chose a STEM major field at some point during their postsecondary enrollment from 2003 to 2009. Many of these STEM entrants—48 percent at the bachelor's degree level and 69 percent at the associate's degree level—exited STEM fields several years later by changing majors or leaving college without completing a degree or certificate. Attrition rates of this magnitude are not unique to STEM fields. At the bachelor's degree level, fields like humanities, education, and health sciences experienced higher attrition rates (56–62 percent) than did STEM fields (48 percent), and business and social/behavioral sciences experienced attrition rates of similar magnitude (50 percent and 45 percent, respectively) as those in STEM fields. At the associate's degree level, the attrition rates in non-STEM fields ranged from 57 percent in health sciences and 66 percent in business to 70 percent in education and 72 percent in humanities, compared with 69 percent in STEM fields.

This report focused on identifying the characteristics associated with STEM attrition. Bivariate analyses showed that STEM attrition was correlated with a wide range of factors, including students' demographic backgrounds, precollege academic preparation, postsecondary enrollment characteristics, and STEM coursetaking and performance. When the study was subjected to a more rigorous multivariate analysis, the findings of the MNP models on STEM attrition yielded more information than was possible to obtain from bivariate analysis.

While bivariate results show that STEM coursetaking and performance was correlated with switching majors to non-STEM fields, the MNP results revealed that taking lighter credit loads in STEM courses in the first year, taking less challenging math courses in the first year, and earning STEM grades that were lower than non-STEM grades were associated with a higher probability of switching majors for STEM entrants at both the bachelor's and associate's degree level after controlling for many factors in the model. Accumulating high levels of withdrawn/failed STEM credits over time was also a significant factor in the probability of bachelor's degree students switching majors.

The MNP results also revealed that exiting STEM fields by leaving college altogether without earning a degree or certificate was more importantly associated with students' overall college performance and their success in STEM courses than many other factors. Poor performance in college (as reflected by a lower cumulative GPA through 2009) and high levels of withdrawn/failed STEM courses were associated with a higher probability of dropping out of college for STEM entrants at both the bachelor's and associate's degree levels. Lower STEM grades relative to non-STEM grades was also associated with an increased probability of dropping out of college for STEM entrants at the associate's degree level.

The MNP analysis also illuminated several other patterns that were different from those in the bivariate results. While the bivariate analysis found that female STEM entrants among both bachelor's and associate's degree students left STEM fields more frequently by switching majors than their male counterparts, the MNP analysis revealed this pattern only among associate's degree students. In addition, the bivariate analysis showed that at the associate's degree level, students from low- or high-income backgrounds had similar rates of leaving STEM fields by switching majors; after controlling for the other variables in the MNP model, however, students from low-income backgrounds were found to have a lower probability of switching majors than those from high-income backgrounds (19 percent vs. 39 percent).

The MNP results further indicated that low- and high-performing STEM entrants may exit STEM fields in different ways. The probability of exiting STEM fields by dropping out of college was higher for low-performing students (i.e., those with an overall college GPA of less than 2.5) than for high-performing students (i.e., those with an overall college GPA of 3.5 or higher), while the probability of leaving STEM fields by switching majors was higher for students in the high-performing group than for their peers in the low-performing group. This finding was consistent for both bachelor's and associate's degree students. The direction of the negative association between college GPA and switching majors cannot be determined from the analysis.

That is, whether high-performing students were more prone to switch majors than low-performing students or whether it was easier for STEM leavers to earn higher grades after switching to a non-STEM field cannot be determined from the data. Nevertheless, the loss of high-performing students from STEM fields has been reported in other studies (Bettinger 2010; Lowell et al. 2009). Some have found that high-performing students abandoned STEM majors for certain non-STEM fields that offer higher earnings (e.g., business and health care) (Bettinger 2010; Shaw and Barbuti 2010). More research is needed to understand the underlying motivation for changing majors, particularly among top students.

Finally, the MNP analysis confirmed several patterns observed among bachelor's degree STEM entrants in the bivariate analysis. All other factors being equal, bachelor's degree STEM entrants who first attended public 4-year institutions had a higher probability of switching majors than those who started at private nonprofit 4-year institutions. Bachelor's degree STEM entrants who were male, came from low-income backgrounds, or first attended the least selective institutions had a higher probability of dropping out of college than their corresponding counterparts who were female, came from high-income backgrounds, or first attended highly selective institutions.

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Appendix A—Glossary

This glossary describes the variables used in this study. These variables were taken directly from the BPS:04/09 PowerStats. PowerStats is an online software application that generates tables from the BPS:04/09 data (see appendix B for a description of PowerStats), and it can be accessed at http://nces.ed.gov/datalab/. In the glossary below, the items are listed in alphabetical order by the variable label. The name of each variable appears to the right of the variable label. Detailed information about how these variables were constructed and their sources can be found at http://nces.ed.gov/datalab.

Glossary Index

Label	**Name**
Sex	GENDER
STEM GPA versus non-STEM GPA in the first year	GPA1DIFF
STEM GPA versus non-STEM GPA through 2009	GPADIFF
Students who entered STEM left these fields by spring 2009	STEMCHG
Time of entrance into STEM field	STEMTIME
Time of entrance into biological/life science field	BIOTIME
Time of entrance into business field	BUSTIME
Time of entrance into computer/information science field	COMPTIME
Time of entrance into education field	EDUTIME
Time of entrance into engineering/technology field	ENGTIME
Time of entrance into health science field	HEATIME
Time of entrance into humanity field	HUMTIME
Time of entrance into mathematics field	MATHTIME
Time of entrance into physical science field	PHYTIME
Time of entrance into social/behavioral science field	SOCTIME

POWERSTATS VARIABLE

BPS:04/06/09 panel weight **WTB000**

The BPS:04/06/09 panel weight was used to produce the estimates in this report. This is the longitudinal study weight used for the analysis of the beginning students for whom sufficient survey data were available to be included as sample members in all 3 years of the BPS interviews (2004, 2006, and 2009).

Degree program in 2003–04 **UGDEG**

Indicates the undergraduate student's degree program during the 2003–04 academic year. It is based primarily on the 2004 interview question; "What degree were you working on at [the National Postsecondary Student Aid Study (NPSAS) sample school]?" For nonrespondents, the degree program reported by the NPSAS institution or reported by the student in the federal financial aid application was used. This variable was edited to ensure that the degree program students reported was actually offered by their institution. Thus students who reported working on a bachelor's degree at a 2-year college were classified as in an associate's degree program and students who reported working on a bachelor's degree or an associate's degree at a less-than-2-year college were classified as in a certificate program. The variable has the following four categories; but this study only selected students enrolling in a bachelor's or associate's degree program.

No degree	The student was not enrolled in a certificate or degree program.
Certificate	The student was enrolled in a certificate program below an associate's degree.
Associate's degree	The student was enrolled in an associate's degree program.
Bachelor's degree	The student was enrolled in a bachelor's degree program.

Field either last enrolled in 2009 or for last degree attained as of 2009 **LSFLD09**

Indicates the major field in which a student was last enrolled in 2009 or the major field for a student's last degree through 2009 if he or she was not enrolled in 2009.

Left postsecondary without a degree or certificate
Was enrolled in STEM
Was enrolled in social/behavioral sciences
Was enrolled in humanities
Was enrolled in business
Was enrolled in education
Was enrolled in health sciences
Was enrolled in other field
Was not enrolled; last degree in STEM
Was not enrolled; last degree in social/behavioral sciences
Was not enrolled; last degree in humanities
Was not enrolled; last degree in business
Was not enrolled; last degree in education
Was not enrolled; last degree in health sciences
Was not enrolled; last degree in other field

POWERSTATS VARIABLE

GPA in all courses taken in the first year **QEYR1GPA**
Indicates normalized grade point average in all courses taken during the first year of enrollment. For some tables, this variable was recoded into the following categories:

Less than 2.50
2.50–2.99
3.00–3.49
3.50 or higher

GPA in all courses taken through 2009 **QEGPAALL**
Indicates normalized grade point average in all courses taken during enrollment through 2009. For some tables, this variable was recoded into the following categories:

Less than 2.50
2.50–2.99
3.00–3.49
3.50 or higher

GPA in all STEM courses taken in the first year **GPA1STEM**
Indicates normalized grade point average in all STEM courses taken during the first year of enrollment. For some tables, this variable was recoded into the following categories:

Less than 2.50
2.50–2.99
3.00–3.49
3.50 or higher

GPA in all STEM courses taken through 2009 **GPASTEM**
Indicates normalized grade point average in all STEM courses taken during enrollment through 2009. For some tables, this variable was recoded into the following categories:

Less than 2.50
2.50–2.99
3.00–3.49
3.50 or higher

High school grade point average (GPA) **HCGPAREP**
Indicates the high school grade point average. This variable is only available for students under age 24 who received a high school diploma, and was recoded into the following categories:

Less than 2.50
2.50–2.99
3.00–3.49
3.50 or higher

POWERSTATS VARIABLE

Highest level of math in which student earned credits in the first year **MATHYR1**

Indicates the highest level of math courses in which a student earned one or more credits during the first year of enrollment. Precollege-level math courses are courses designed to provide students with the background and foundation skills necessary to succeed in college-level math courses. Typical precollege-level math courses include arithmetic, beginning or intermediate algebra, plane geometry, and developmental/remedial math. Introductory college-level math courses are initial or entry-level college math courses that represent essential prerequisites for students who need to progress to advanced math courses and students whose degrees require an introduction to more rigorous mathematics. These courses are commonly referred to as “gatekeeper” or “gateway” courses. See appendix D for a detailed listing of math courses in each level.

No math
Precollege-level math only
Precollege-level math plus college-level math
College-level math/statistics only
Calculus or advanced math

Highest level of math in which student earned credits through 2009 **MATHYR**

Indicates the highest level of math courses in which a student earned one or more credits during enrollment through 2009. Precollege-level math courses are courses designed to provide students with the background and foundation skills necessary to move on to and succeed in their college-level math courses. Typical courses in this level include arithmetic, beginning or intermediate algebra, plane geometry, and developmental/remedial math. Introductory college-level math courses are initial or entry-level college math courses that represent essential prerequisites for students who need to progress to advanced math courses and those whose degrees require an introduction to more rigorous mathematics. These courses are commonly referred to as “gatekeeper” or “gateway” courses. See appendix D for a detailed listing of different levels of math courses.

No math
Precollege-level math only
Precollege-level math plus college-level math
College-level math/statistics only
Calculus or advanced math

Highest level of math taken in high school **HCMATH**

Indicates the highest level of math course that a student took in high school. This variable is only available for students under age 24.

None of these
Algebra 2
Trigonometry/Algebra 2
Precalculus
Calculus

POWERSTATS VARIABLE

Income level in 2003–04 **INCGRP2**

Indicates the income level of independent students or parents of dependent students during the 2003–04 academic year.

Lowest 25 percent
Lower middle 25 percent
Upper middle 25 percent
Highest 25 percent

Level and control of institution first attended in 2003–04 **FSECTOR**

Indicates the level and control of the first institution attended by the student during the 2003–04 academic year, based on the classification in the 2003 Integrated Postsecondary Education Data System (IPEDS) Institutional Characteristics file. Control concerns the source of revenue and control of operations (public, private nonprofit, for-profit), and level concerns the highest degree or award offered by the institution in any program.

- 4-year
  - Public
  - Private nonprofit
  - For-profit
- 2-year
  - Public
  - Private nonprofit
  - For-profit
- Less-than-2-year
  - Public
  - Private nonprofit
  - For-profit

Number of STEM credits attempted in the first year **STEMATT1**

Indicates the total number of STEM credits attempted by a student during the first year of enrollment.

Number of STEM credits attempted through 2009 **STEMATT**

Indicates the total number of STEM credits attempted by a student during enrollment through 2009.

Number of STEM credits earned in the first year **STEMERN1**

Indicates the total number of STEM credits earned by a student during the first year of enrollment.

Number of STEM credits earned through 2009 **STEMERN**

Indicates the total number of STEM credits earned by a student during enrollment through 2009.

Number of years through 2009 in which student received Pell Grant **PELYRS09**

Indicates the number of years a student received a Pell Grant during their enrollment through 2009. This variable was recoded into the following categories:

Received a Pell Grant through 2009
Did not receive a Pell Grant through 2009

POWERSTATS VARIABLE

Parents' highest level of education **PAREDUC**
Indicates the highest level of education completed by the student's mother or father, whoever had the highest level. This variable was recoded into the following categories:

High school or less	Student's parents earned a high school diploma or equivalent or did not complete high school.
Some postsecondary	Student's parents attended some postsecondary education, but did not earn a bachelor's degree.
Bachelor's degree or higher	Student's parents attained a bachelor's or advanced degree.

Percentage of STEM credits earned in total credits earned in the first year **STVSTOT1**
Indicates the total number of STEM course credits divided by all course credits earned during the first year of enrollment.

Percentage of STEM credits earned in total credits earned through 2009 **STVSTOT**
Indicates the total number of STEM course credits divided by all course credits earned during enrollment through 2009.

Percentage of withdrawn/failed non-STEM courses in all non-STEM courses in the first year **WNSMRA1**
Indicates the total number of non-STEM courses withdrawn or failed to complete divided by all non-STEM courses attempted during the first year of enrollment.

Percentage of withdrawn/failed non-STEM courses in all non-STEM courses through 2009 **WNSTEMRA**
Indicates the total number of non-STEM courses withdrawn or failed to complete divided by all non-STEM courses attempted during enrollment through 2009.

Percentage of withdrawn/failed STEM courses in all STEM courses in the first year **WSTEMRA1**
Indicates the total number of STEM courses withdrawn or failed to complete divided by all STEM courses attempted during the first year of enrollment.

Percentage of withdrawn/failed STEM courses in all STEM courses through 2009 **WSTEMRA**
Indicates the total number of STEM courses withdrawn or failed to complete divided by all STEM courses attempted during enrollment through 2009.

Race/ethnicity **RACE**
Indicates a student's race/ethnicity with Hispanic or Latino origin as a separate category. All of the race categories exclude Hispanic origin unless specified.

White	A person having origins in any of the original peoples of Europe, North Africa, or the Middle East.
Black	A person having origins in any of the black racial groups of Africa.
Hispanic	A person of Mexican, Puerto Rican, Cuban, Central or South American, or other Spanish culture or origin, regardless of race.

POWERSTATS VARIABLE

Race/ethnicity—continued **RACE**

Asian	A person having origins in any of the peoples of the Far East, Southeast Asia, or the Indian subcontinent. This includes people from China, Japan, Korea, the Philippine Islands, India, and Vietnam.
All other races	Includes persons reporting origins in any of the original peoples of North America and who maintain cultural identification through tribal affiliation or community recognition (American Indians), Alaska Natives, persons having origins in the Pacific Islands including Hawaii and Samoa, persons reporting having origins in race not listed above, and persons reporting origins in more than one race.

Selectivity of 4-year institution first attended in 2003–04 **SELECTV2**

Indicates the level of selectivity of the public or private nonprofit 4-year institution attended by the student during the 2003–04 academic year. The selectivity of institution was developed only for public and private nonprofit 4-year institutions using the following criteria: whether the institution was open admission (had no minimal requirements); the number of applicants; the number of students admitted; the 25th and 75th percentiles of ACT and/or SAT scores; and whether test scores were required for admission. For more information, see Cunningham, A.F. (2006). *Changes in Patterns of Prices and Financial Aid* (NCES 2006-153). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC. For this study, this variable was recoded into the following categories, and the last category, "minimally selective/open admission," includes for-profit 4-year institutions.

Very selective
Moderately selective
Minimally selective/open admission

Sex **GENDER**

Indicates the sex of a student.

Male
Female

STEM GPA versus non-STEM GPA in the first year **GPA1DIFF**

Indicates the difference between STEM GPA and non-STEM GPA during the first year of enrollment.

STEM GPA lower than non-STEM GPA by at least one grade point
STEM GPA lower than non-STEM GPA by 0.5 to 1.0 grade point
STEM GPA about the same as non-STEM GPA
STEM GPA higher than non-STEM GPA by 0.5 to 1.0 grade point
STEM GPA higher than non-STEM GPA by at least 1.0 grade point

POWERSTATS VARIABLE

STEM GPA versus non-STEM GPA through 2009 **GPADIFF**
Indicates the difference between STEM GPA and non-STEM GPA during enrollment through 2009.

STEM GPA lower than non-STEM GPA by at least one grade point
STEM GPA lower than non-STEM GPA by 0.5 to 1.0 grade point
STEM GPA about the same as non-STEM GPA
STEM GPA higher than non-STEM GPA by 0.5 to 1.0 grade point
STEM GPA higher than non-STEM GPA by at least 1.0 grade point

Students who entered STEM left these fields by spring 2009 **STEMCHG**
Indicates whether a student who entered a STEM field between 2003 and 2009 persisted in or left STEM as of spring 2009.

Left postsecondary education with no degree or certificate
Changed to non-STEM field
Stayed in STEM field

Time of entrance into STEM field **STEMTIME**
Indicates a time period that a student entered a STEM field between 2003 and 2009. Entrance was defined as a student choosing a STEM major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

Time of entrance into biological/life science field **BIOTIME**
Indicates a time period that a student entered a biological/life science field between 2003 and 2009. Entrance was defined as a student choosing a biological/life science major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

Time of entrance into business field **BUSTIME**
Indicates a time period that a student entered a business field between 2003 and 2009. Entrance was defined as a student choosing a business major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

Time of entrance into computer/information science field **COMPTIME**
Indicates a time period that a student entered a computer/information science field between 2003 and 2009. Entrance was defined as a student choosing a computer/information major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

POWERSTATS VARIABLE

Time of entrance into education field **EDUTIME**

Indicates a time period that a student entered an education field between 2003 and 2009. Entrance was defined as a student choosing an education major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

Time of entrance into engineering/technology field **ENGTIME**

Indicates a time period that a student entered an engineering, engineering technology, or science technology field between 2003 and 2009. Entrance was defined as a student choosing an engineering/engineering technology/science technology major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

Time of entrance into health science field **HEATIME**

Indicates a time period that a student entered a health science field between 2003 and 2009. Entrance was defined as a student choosing a health science major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

Time of entrance into humanity field **HUMTIME**

Indicates a time period that a student entered a humanity field between 2003 and 2009. Entrance was defined as a student choosing a humanity major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

Time of entrance into mathematics field **MATHTIME**

Indicates a time period that a student entered a mathematics field between 2003 and 2009. Entrance was defined as a student choosing a math major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

Time of entrance into physical science field **PHYTIME**

Indicates a time period that a student entered a physical science field between 2003 and 2009. Entrance was defined as a student choosing a physical science major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

POWERSTATS VARIABLE

Time of entrance into social/behavioral science field **SOCTIME**

Indicates a time period that a student entered a social/behavioral science field between 2003 and 2009. Entrance was defined as a student choosing a social/behavioral science major between 2003 and 2009.

Between 2003 and 2004
Between 2004 and 2006
Between 2006 and 2009

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Appendix B—Technical Notes and Methodology

Data Sources

The analysis presented in this SAR is based on data from the 2004/09 Beginning Postsecondary Students Longitudinal Study (BPS:04/09) and its 2009 Postsecondary Education Transcript Study (PETS:09) component. BPS is conducted for the U.S. Department of Education's National Center for Education Statistics (NCES) to provide nationally representative data on key postsecondary education issues. It focuses on a nationally representative sample of students who are enrolled in postsecondary education for the first time, explores topics related to postsecondary enrollment and persistence in the United States, and addresses the benefits of postsecondary education to individuals and society (Radford et al. 2010). The BPS:04/09 is the latest in the series of administrations of BPS. The two previous studies were conducted between 1990 and 1994 (BPS:90/94) and between 1996 and 2001 (BPS:96/2001).

BPS:04/09

BPS:04/09 began with a nationally representative sample of students who entered postsecondary education for the first time in the 2003–04 academic year. The initial sample of approximately 19,000 first-time beginning students was drawn from the 2003–04 National Postsecondary Student Aid Study (NPSAS:04). These students were then followed at three time points: in 2004, at the end of their first year in postsecondary education; in 2006, approximately 3 years after they had started postsecondary education; and in 2009, approximately 6 years after they had started. The final BPS:04/09 dataset contains information on nearly 16,700 students with an overall weighted response rate of 89 percent (Radford et al. 2010).

In the 2004 interview, first-time beginning students were asked a variety of questions regarding their academic and social experiences during the first year, their work while enrolled, their education plans and long-term goals, their demographic characteristics, and their family responsibilities and backgrounds. The 2006 interview focused on students' enrollment patterns since 2004, including transfers, stopout periods, attendance intensity, and completion of certificates and degrees. Those who were no longer enrolled were asked about their employment experiences. The last interview in 2009 focused on the degree completion of those still enrolled after 2006, graduate school enrollment of those who had completed bachelor's degrees, and employment of those no longer enrolled. In all 3 study years, student interviews were conducted via web-based questionnaires that were either self-administered or conducted via telephone with a trained interviewer.

Besides interview data, BPS:04/09 also collected information from other sources, including data provided by respondents' NPSAS:04 institutions, the Integrated Postsecondary Education Data System (IPEDS), the National Student Loan Data System (NSLDS), the College Board and ACT, and the National Student Clearinghouse (NSC). Together, these data provide information on students' demographic characteristics, their persistence in and completion of postsecondary education programs, their transition into employment, and changes over time in their goals, marital status, income, and debt, among other indicators.

PETS:09

Postsecondary transcripts were collected as part of BPS:04/09. Transcripts were requested from 3,030 eligible postsecondary institutions that members of the BPS:04/09 sample attended between July 1, 2003, and June 30, 2009. These institutions included those reported by sample members in the first and second follow-up interviews as well as those identified on other transcripts received for sample members. Of the eligible institutions, 2,620 (87 percent) provided transcripts for the cohort, resulting in 16,960 PETS sample members (92 percent) with at least one transcript available for analysis. The transcripts provided a detailed portrait of students' enrollment, coursetaking, credit accumulation, academic performance, and degree histories. For additional information on BPS:04/09 and the associated PETS:09 transcript collection, see Wine, Janson, and Wheeless (2011).

Response Rates and Bias Analysis

NCES Statistical Standards require that nonresponse bias analysis be conducted if the response rate at any level (institutions, students, items) is below 85 percent (U.S. Department of Education 2002). Below is a brief discussion about transcript collection response rates at the three levels that are pertinent to this study. For detailed information about response rates and related bias analysis, see Wine, Janson, and Wheeless (2011).

Institution, Student, and Item Response Rates

NCES Statistical Standard 4-4-1 states that "[a]ny survey stage of data collection with a unit or item response rate less than 85 percent must be evaluated for the potential magnitude of nonresponse bias before the data or any analysis using the data may be released" (U.S. Department of Education 2002). In the case of BPS:04/09, this means that nonresponse bias analysis could be required at any of three levels: institutions, study respondents, or items.

For BPS:04/09, the overall institution response rate at the base year was 80 percent (see Wine, Janson, and Wheeless 2011, table 45). Institution nonresponse bias was performed as a part of NPSAS:04 and is described in the NPSAS:04 Full-scale Methodology Report (Cominole et al. 2006). Of the 3,030 eligible institutions attended by the BPS:04/09 cohort, 2,620 institutions provided at least one transcript for a cohort member, resulting in a response rate of 87 percent (see Wine, Janson, and Wheeless 2011, table 26).

Overall, 89 percent of the eligible BPS:04/09 sample were study respondents; 86 percent of the eligible panel sample (i.e., study respondents to all three of NPSAS:04, BPS:04/06, and BPS:04/09) responded to all three BPS:04/09 interviews; and at least one transcript was collected from 91 percent of the eligible students (see Wine, Janson, and Wheeless 2011, table 45). Table B-1 displays the item-level response rates for all student-level derived variables used in this report, and all of them have an item-level response rate above 85 percent.

Weighting

All estimates in this report were weighted to compensate for unequal probability of selection into the survey sample and to adjust for nonresponse. The weight variable used for analysis of the BPS:04/09 and PETS:09 data was WTB000, a longitudinal weight designed for 2003–04 beginning postsecondary students who also participated in the two follow-up surveys.[25]

[25] All tables in this report include both student interview and transcript data; hence WTB000 is a more proper weight variable than WTC000, which is used only when transcript data are involved (Wine, Janson, and Wheeless 2011).

Table B-1.
Item response rates and nonresponse rates for student-level variables used in this study

Variable	Description	Item response rate	Item non-response rate
ACG1[1]	ACG curriculum eligibility 2003−04	100.0	0.0
UGDEG	Degree program in 2003−04	100.0	0.0
LSFLD09	Field either last enrolled in 2009 or for last degree attained as of 2009	92.1	7.9
QEYR1GPA	GPA in all courses taken in first year	95.5	4.5
QEGPAALL	GPA in all courses taken through 2009	95.7	4.3
GPA1STEM	GPA in all STEM courses taken in first year	96.6	3.4
GPASTEM	GPA in all STEM courses taken through 2009	98.1	1.9
HCGPAREP[2]	High school grade point average (GPA)	100.0	0.0
MATHYR1	Highest level of math in which student earned credits in first year	95.3	4.7
MATHYR	Highest level of math in which student earned credits through 2009	98.0	2.0
HCMATH[1]	Highest level of math taken in high school	100.0	0.0
INCGRP2	Income group in 2003−04	100.0	0.0
FSECTOR	Level and control of institution first attended in 2003−04	100.0	0.0
STEMATT1	Number of STEM credits attempted in first year	96.8	3.2
STEMATT	Number of STEM credits attempted through 2009	98.9	1.1
STEMERN1	Number of STEM credits earned in first year	95.4	4.6
STEMERN	Number of STEM credits earned through 2009	98.2	1.8
PELYRS09	Number of years through 2009 in which student received Pell Grant	100.0	0.0
PAREDUC	Parents' highest level of education	97.3	2.7
STVSTOT1	Percentage of STEM credits earned in total credits earned in first year	95.6	4.4
STVSTOT	Percentage of STEM credits earned in total credits earned through 2009	98.1	1.9
WNSMRA1	Percentage of withdrawn/failed non-STEM courses in all non-STEM courses in first year	100.0	0.0
WNSTEMRA	Percentage of withdrawn/failed non-STEM courses in all non-STEM courses through 2009	100.0	0.0
WSTEMRA1	Percentage of withdrawn/failed STEM courses in all STEM courses in first year	100.0	0.0
WSTEMRA	Percentage of withdrawn/failed STEM courses in all STEM courses through 2009	100.0	0.0
RACE	Race/ethnicity	100.0	0.0
SELECTV2	Selectivity of institution first attended in 2003−04	99.8	0.2
GENDER	Sex	100.0	0.0
GPA1DIFF	STEM GPA versus non-STEM GPA in first year	96.4	3.6
GPADIFF	STEM GPA versus non-STEM GPA through 2009	98.1	1.9
STEMCHG	Students who entered STEM left these fields by spring 2009	94.0	6.0
BIOTIME	Time of entrance into biological/life science field	100.0	0.0
BUSTIME	Time of entrance into business field	100.0	0.0
COMPTIME	Time of entrance into computer/information science field	100.0	0.0
EDUTIME	Time of entrance into education field	100.0	0.0
ENGTIME	Time of entrance into engineering/technology field	100.0	0.0
HEATIME	Time of entrance into health science field	100.0	0.0
HUMTIME	Time of entrance into humanity field	100.0	0.0

See notes at end of table.

Table B-1.
Item response rates and nonresponse rates for student-level variables used in this study—continued

Variable	Description	Item response rate	Item non-response rate
MATHTIME	Time of entrance into mathematics field	100.0	0.0
PHYTIME	Time of entrance into physical science field	100.0	0.0
SOCTIME	Time of entrance into social/behavioral science field	100.0	0.0
STEMTIME	Time of entrance into STEM field	100.0	0.0

[1] Information on this variable was not collected for about 21 percent of students age 24 or above. These students were not treated as “missing” and included in the “skip” category in table 2.

[2] Information on this variable was not collected for about 27 percent of students who were age 24 or above or did not receive a high school diploma. These students were not treated as “missing” and included in the “skip” category in various tables.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. The item response and nonresponse rates were computed using the BPS:04/09 study respondent panel weight (WTB000) if the item was based on student interview and transcript data or student transcript analysis weight (WTC000) if the item was based only on transcript data. The response rate was computed as the number of cases who responded to the item and did not have a legitimate skip for the item divided by the number of cases who did not have a legitimate skip for the item.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09) and Postsecondary Education Transcript Study of 2009 (PETS:09).

Statistical Procedures

Differences Between Two Estimates

The descriptive comparisons of two estimates (e.g., means and proportions) were tested using Student’s *t* statistic. Differences between estimates were tested against the probability of a Type I error[26] or significance level. The statistical significance of each comparison was determined by calculating the Student’s *t* value for the difference between each pair of estimates and comparing the *t* value with published tables of significance levels for two-tailed hypothesis testing. Student’s *t* values were computed to test differences between independent estimates using the following formula:

$$t = \frac{E_1 - E_2}{\sqrt{se_1^2 + se_2^2}}$$

There are some hazards in reporting statistical tests for each comparison. First, comparisons based on large *t* statistics may appear to merit special attention. This can be misleading because the magnitude of the *t* statistic is related not only to the observed differences in estimates but also to the number of respondents in the

[26] A Type I error occurs when one concludes that a difference observed in a sample reflects a true difference in the population from which the sample was drawn, when no such difference is present.

specific categories used for comparison. Hence, a small difference compared across a large number of respondents would produce a large (and thus possibly statistically significant) *t* statistic.

A second hazard in reporting statistical tests is the possibility that one can report a "false positive" or Type I error. Statistical tests are designed to limit the risk of this type of error using a value denoted by alpha. The alpha level of .05 was selected for findings in this report and ensures that a difference of a certain magnitude or larger would be produced when there was no actual difference between the quantities in the underlying population no more than 1 time out of 20. When analysts test hypotheses that show alpha values at the .05 level or smaller, they reject the null hypothesis that there is no difference between the two estimates. Failing to reject a null hypothesis (i.e., failing to detect a difference), however, does not imply the values are the same or equivalent.

Multinomial Probit Regression

This study's final question was addressed via multinomial probit (MNP) regression. In contrast to some regression analyses that seek to validate a particular model or identify causal relationships between one or more independent variables and an outcome of interest, this analysis was undertaken to identify the residual association of a variable with STEM attrition net of other potentially important student and institutional characteristics. MNP is chosen because the outcome of interest has multiple discrete categories. MNP is one of the most common statistical techniques used to predict the probability of an event that would occur or the probability of a respondent choosing a certain outcome out of several mutually exclusive alternatives[27] (Borooah 2001; Koop 2008). Assuming that each individual faces a set of outcomes, an MNP model formulation may be written as follows:

$$y_{ij}^{*} = x_i^{'}\beta_j + \varepsilon_{ij}$$

where i (=1, 2, …, N) represents an individual; j (=1, 2, …, M) represents one of M different outcomes of the dependent variable y_i; x_i' is a vector of independent variables that may be associated with or influence an individual's outcome or choice;

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[27] This report uses a probit rather than a logit model because probit models do not require an assumption of independence of irrelevant alternatives (IIA). IIA implies that the preferences between alternatives A and B depend only on the individual preferences between A and B. In other words, if A is preferred to B out of the choice set {A,B}, then introducing a third alternative C and thus expanding the choice set to {A,B,C}, must not change the preferences between A and B (i.e., A is still preferred to B after the inclusion of C). A MNP model relaxes this requirement and allows more flexibility in which outcomes are considered in the analysis.

and the error term, ϵ_i's, are assumed to follow a multivariate normal distribution. MNP assumes that each individual chooses the option yielding the highest utility of all alternatives. That is, an individual *i* chooses the outcome *j* if the outcome y_{ij}^* is the highest for *j*:

$$y_i = \begin{cases} j \text{ if } y_{ij}^* = \max(y_{i1}^*, y_{i2}^*, \ldots, y_{iM}^*) \\ 0 \text{ otherwise.} \end{cases}$$

The probability of an individual *i* choosing outcome *j* is conditional on or a function of the set of independent variables, x_i's:

$$p(y_i = j \mid x_i) = F_j(x_i', \varepsilon_i) \text{ (j = 1,…, M, i = 1,…, N)}$$

where for a probit analysis, F represents a cumulative probability function based on the normal distribution. Only M−1 of the probabilities can be freely specified because the probability for all alternatives sum to one (i.e., $p(y_i = 1) + p(y_i = 2) + \ldots + p(y_i = M) = 1$).

The parameters of MNP models are generally not directly interpretable. Instead, researchers often rely on marginal effects (ME) to interpret MNP results (Liao 1994). An ME measures the change in the probability that alternative *j* is the outcome when one of the independent variables changes by one unit. For a categorical variable, the ME measures the change in the probability of the outcome that would occur if this categorical variable changes from 0 (reference category) to 1 (category of interest), holding all other independent variables constant. For a continuous independent variable, the ME measures the instantaneous rate of change, which typically depends on the position or value of the continuous variable. In this case, the average ME, which is the mean value of MEs corresponding to all values of this continuous independent variable, is recommended to use.

The MNP analysis in this study mainly focuses on STEM attrition, examining the probability of STEM entrants switching to non-STEM fields or leaving college without earning a degree or certificate as opposed to completing or persisting in STEM fields. Because the way that STEM entrants left their fields may be different from that for non-STEM entrants, this study also ran a similar MNP model for non-STEM entrants, examining their probability of leaving college without earning a degree or certificate as opposed to completing or persisting in postsecondary education. While it is impossible to compare these two models directly, the second model provides a large context regarding the factors associated with students leaving college without earning a degree or certificate.

MNP Analysis for Non-STEM Entrants Leaving Postsecondary Education Without a Degree or Certificate

Table B-2 presents the MNP results for non-STEM entrants leaving postsecondary education without a degree or certificate. The base category is “persisting in postsecondary education” (i.e., either attaining a degree or certificate or still enrolling in postsecondary education as of 2009). The analysis was conducted separately for bachelor’s and associate’s degree students.

Table B-2.
Average marginal effects of various characteristics on the probability of students leaving postsecondary education without a degree or certificate among 2003–04 beginning bachelor’s and associate’s degree students who did not enter STEM fields between 2003 and 2009, and the average predicted probability of leaving postsecondary education without a degree or certificate among various groups of non-STEM entrants

	Non-STEM entrants among beginning bachelor’s degree students		Non-STEM entrants among beginning associate’s degree students	
Characteristic	Average marginal effect[1]	Average predicted probability[2]	Average marginal effect[1]	Average predicted probability[2]
Demographic characteristics				
Sex				
Female	0.02	20.5	-0.01	41.2
Male	†	18.4	†	*42.1*
Race/ethnicity[3]				
Black	-0.02	18.6	-0.09	35.5 *
Hispanic	-0.02	18.0	-0.03	41.8
Asian	0.00	20.3	-0.15	29.2 **
All other races	-0.03	17.3	-0.10	34.7
White	†	20.3	†	*44.4*
Highest education of parents				
High school or less	0.03	21.0	-0.01	42.9
Some college	0.03	20.9	-0.06	37.7
Bachelor’s degree or higher	†	18.3	†	*43.9*
Income level in 2003–04[4]				
Lowest 25 percent	0.06	23.4 *	0.09	45.6 *
Lower middle 25 percent	0.01	18.9	0.05	40.7
Upper middle 25 percent	0.02	19.5	0.07	42.7
Highest 25 percent	†	17.7	†	36.1
Precollege academic preparation				
Highest mathematics in high school[5]				
Skipped	0.15	37.4	-0.07	47.1
None of the following	-0.06	16.5	-0.15	39.3 *
Algebra II/trigonometry	-0.04	18.1 *	-0.16	37.9 *
Pre-calculus	-0.04	19.0	-0.12	42.2
Calculus	†	22.6	†	*53.9*
High school GPA[6]				
Skipped	-0.03	16.6	0.11	48.0
Less than 2.50	-0.05	14.5	0.09	46.3
2.50–2.99	0.03	23.0	-0.02	35.9
3.00–3.49	0.01	20.4	-0.02	35.9
3.50 or higher	†	19.5	†	*37.5*

See notes at end of table.

Table B-2.
Average marginal effects of various characteristics on the probability of students leaving postsecondary education without a degree or certificate among 2003−04 beginning bachelor's and associate's degree students who did not enter STEM fields between 2003 and 2009, and the average predicted probability of leaving postsecondary education without a degree or certificate among various groups of non-STEM entrants—continued

Characteristic	Non-STEM entrants among beginning bachelor's degree students		Non-STEM entrants among beginning associate's degree students	
	Average marginal effect[2]	Average predicted probability[3]	Average marginal effect[2]	Average predicted probability[3]
Type of institution first attended				
Selectivity of 4-year institution first attended[7]				
Minimally selective/open admission	0.09	24.8 **	—	—
Moderately selective	0.03	19.1	—	—
Very selective	†	16.0	—	—
Level and control of institution first attended				
Private nonprofit 4-year	0.01	20.5	—	—
For-profit 4-year	0.00	19.6		
Public 4-year	†	19.3	—	—
Level and control of institution first attended				
Private 2-year	—	—	0.00	41.5
Other[8]	—	—	-0.04	38.4
Public 2-year	—	—	†	*41.9*
First-year STEM coursetaking and performance				
Percent of STEM credits in all credits earned in first year				
Lower than 25 percent	-0.05	18.8	-0.10	39.3 *
25−49 percent	-0.04	20.0	-0.09	40.8 *
50 percent or higher	†	24.2	†	*49.3*
Highest mathematics in first year[9]				
No math	0.04	21.6	0.20	45.4 **
Precollege-level math	0.03	20.1	0.18	43.1 *
Introductory math	0.01	18.6	0.12	37.5
Calculus/advanced math	†	17.3	†	25.1
STEM GPA compared to non-STEM GPA in first year				
Lower by at least 1.0 grade point	-0.03	17.5	-0.03	39.9
Lower by 0.5 to 0.9 grade point	-0.01	19.3	-0.04	39.0
About the same or higher[10]	†	20.8	†	*42.7*
Performance through 2009				
Percent of withdrawn/failed non-STEM courses out of all non-STEM courses attempted through 2009				
10 percent or higher	0.08	26.4 **	0.07	46.8 **
Less than 10 percent	†	18.0	†	*39.4*
GPA through 2009				
Less than 2.50	0.41	46.4 ***	0.41	63.1 ***
2.50–2.99	0.14	19.5 ***	0.19	41.4 ***
3.00–3.49	0.04	9.6 **	0.06	28.0
3.50 or higher	†	5.2	†	*22.1*
STEM GPA compared to non-STEM GPA through 2009				
Lower by at least 1.0 grade point	0.08	26.3 **	0.02	44.4
Lower by 0.5 to 0.9 grade points	0.01	19.5	-0.06	36.3
About the same or higher[10]	†	18.0	†	*42.4*

See notes at end of table.

Table B-2.
Average marginal effects of various characteristics on the probability of students leaving postsecondary education without a degree or certificate among 2003−04 beginning bachelor's and associate's degree students who did not enter STEM fields between 2003 and 2009, and the average predicted probability of leaving postsecondary education without a degree or certificate among various groups of non-STEM entrants—continued

* $p < .05$, ** $p < .01$, *** $p < .001$.
† Not applicable for the comparison group.
— Not applicable.
[1] Marginal effect measures the average percentage point change in the predicted probability of leaving postsecondary education without a degree or certificate associated with a one unit change in an independent variable, after controlling for the covariation of the variables in the model.
[2] Average probability of leaving postsecondary education without a degree or certificate after controlling for the covariation of the variables in the model.
[3] Black includes African American, Hispanic includes Latino, and "All other races" includes American Indian, Alaska Native, Native Hawaiian, other Pacific Islanders, and individuals who indicated Two or more races or Other.
[4] Total income in 2002 for independent students or parents of dependent students.
[5] Information for this variable is only available for students under age 24. Those age 24 or above (about 16 percent of the study sample) were included in the "skip" category.
[6] Information for this variable is only available for students under age 24 who received a high school diploma. Those age 24 or above or without a high school diploma (about 21 percent of the study sample) were included in the "skip" category.
[7] The selectivity of institution was developed only for public and private nonprofit 4-year institutions using the following criteria: whether the institution was open admission (no minimal requirements); the number of applicants; the number of students admitted; the 25th and 75th percentiles of ACT and/or SAT scores; and whether or not test scores were required. For more information, see Cunningham, A.F. (2006). *Changes in Patterns of Prices and Financial Aid* (NCES 2006-153). National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education. Washington, DC. In this table, for-profit 4-year institutions are included in the category of "minimally selective/open admission."
[8] Includes all 4-year and less-than-2-year institutions.
[9] Precollege-level math courses are courses designed to provide students the background and foundation skills necessary to succeed in college-level math courses. Typical precollege level math courses include arithmetic, beginning or intermediate algebra, plane geometry, and developmental/remedial math. Introductory math courses are initial or entry-level college math courses that represent essential prerequisites for students who need to progress to advanced math courses and students whose degrees require an introduction to more rigorous mathematics. These courses are commonly referred to as "gatekeeper" or "gateway" courses. See appendix D for a detailed listing of math courses in each level.
[10] "About the same or higher" means that STEM and non-STEM GPAs are the same or different by less than 0.5 point or STEM GPA is higher than non-STEM GPA by at least 0.5 point.

NOTE: STEM (science, technology, engineering, and mathematics) includes mathematics, physical sciences, biological/life sciences, engineering/engineering technologies, science technologies, and computer/information sciences. The table includes beginning bachelor's and associate's degree students who did not enter STEM fields between 2003 and 2009. The italicized category in each variable is the comparison group. Estimates include students enrolled in Title IV eligible postsecondary institutions in the 50 states, the District of Columbia, and Puerto Rico.

SOURCE: U.S. Department of Education, National Center for Education Statistics, 2003/04 Beginning Postsecondary Students Longitudinal Study, Second Follow-up (BPS:04/09), and Postsecondary Education Transcript Study of 2009 (PETS:2009).

About PowerStats

All bivariate descriptive estimates presented in this report were produced using PowerStats, a web-based software application that allows users to generate tables for many of the postsecondary surveys conducted by NCES.[28] PowerStats produces the design-adjusted standard errors necessary for testing the statistical significance of differences in the estimates.[29] PowerStats also provides the user with detailed information on how each variable was constructed, including question wording for

[28] All estimates for the MNP regressions were generated by Stata using the linearized variance method.
[29] The BPS samples are not simple random samples; therefore, simple random sample techniques for estimating sampling error cannot be applied to these data. PowerStats takes into account the complexity of the sampling procedures and calculates standard errors appropriate for such samples. The method for computing sampling errors used by PowerStats approximates the estimator by replication of the sampled population, using a bootstrap technique.

items coming directly from an interview and the data source(s) used to create the variable.

With PowerStats, users can replicate or expand upon the tables presented in this report. The output from PowerStats includes the table estimates (e.g., percentages or means), standard errors, and weighted sample sizes for the estimates. If the number of valid cases is too small to produce a reliable estimate (fewer than 30 cases), PowerStats prints the double dagger symbol (‡) instead of the estimate.

In addition to producing tables, PowerStats users can conduct linear or logistic regressions. For a description of all the options available, users should access the PowerStats website (http://nces.ed.gov/datalab/index.aspx). For more information about using PowerStats, contact powerstats@ed.gov or

National Center for Education Statistics
NCES.Info@ed.gov

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Appendix C—Classification of Major Field of Study in BPS:04/09

Major field categories used in this study	Major field categories in BPS:04/09[a]
Science, technology, engineering, and mathematics (STEM)	Mathematics
	Physical sciences (including other natural sciences)
	Biological/life sciences
	Agriculture and related sciences
	Natural resources and conservation
	Biological and biomedical sciences
	Engineering/technologies
	Engineering
	Engineering technologies
	Science technologies
	Computer and information sciences
Social/behavioral sciences	Economics
	Geography
	International relations and affairs
	Political science and government
	Sociology
	Other social sciences, psychology
	History[b]
Humanities	English language and literature/letters
	Foreign languages, literatures, and linguistics
	Liberal arts and sciences, general studies, humanities
	Area, ethnic, cultural, and gender studies
	Philosophy, theology, and religious studies
Business	Business, management, marketing, related support services
Education	Education
Health sciences	Health professions and related sciences
	Residency programs

[a] Categories based on the 2000 edition of Classification of Instructional Programs (CIP). For more information on CIP, see http://nces.ed.gov/pubs2002/cip2000/ciplist.asp.

[b] History majors were combined with social sciences majors in BPS:04/09.

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Appendix D—Classification of Postsecondary STEM Courses in BPS:04/09

STEM course category used in the study	Specific course (CIP code[a]) in BPS:04/09
Precollege-level mathematics	Descriptive Geometry, Precollegiate Geometry, Plane Geometry (27.0195)
	Arithmetic (27.0196)
	Intermediate Algebra, Precollegiate Algebra, Elementary Algebra/Basic Algebra (27.0197)
	Precollegiate Math, Basic Concepts of Math, Elementary Math, Introductory Math, Developmental Math, Preparatory Math (27.0198)
	Business Math, Precollegiate Math, Business Computations, Business Arithmetic, Consumer Math (27.9990)
	Developmental/Remedial Mathematics (32.0104)
Introductory college-level mathematics	Mathematics, General (27.0101)
	Algebra and Number Theory (27.0102)
	Geometry/Geometric Analysis (27.0104)
	Mathematics, Other (27.0199)
	Applied Mathematics, General (27.0301)
	Computational Mathematics (27.0303)
	Financial Mathematics (27.0305)
	Applied Mathematics, Other (27.0399)
	Number Systems, Number Structures, Mathematical Structures, Algebra for Teachers, Geometry for Teachers (27.9988)
	Collegiate Business Math, Math for Business, Math for Economics, Math Accounting, Business Algebra (27.9989)
	Technical Math: Using Scientific Calculators (27.9991)
	Math Appreciation, Mathematics in Society, Math in the Modern World, Uses of Math, Cultural Mathematic and/or Survey of Mathematical Thought (27.9992)
	Technical Math, Vocational Math, Physical Measurements, Merchandising Math, Nursing Math, Shop Math and/or Math for Electronics (27.9993)
	Trigonometry (27.9997)

STEM course category used in the study	Specific course (CIP code[a]) in BPS:04/09
Introductory college level mathematics—cont.	Math for Behavior, Math for Economics, Math for Social Science, Contemporary Math (27.9998)
	Educational Statistics and Research Methods (13.0603)
	Biometry/Biometrics (26.1101)
	Biostatistics (26.1102)
	Financial Mathematics (27.0305)
	Statistics, General (27.0501)
	Mathematical Statistics and Probability (27.0502)
	Mathematics and Statistics (27.0503)
	Statistics, Other (27.0599)
	Mathematics and Statistics, Other (27.9999)
	Psychometrics and Quantitative Psychology (42.2708)
	Econometrics and Quantitative Economics (45.0603)
	Social Statistics, Statistics for Social Sciences, Quantitative Research in Social Science (45.9998)
	Business Statistics (52.1302)
Calculus/advanced mathematics	Analysis and Functional Analysis (27.0103)
	Topology and Foundations (27.0105)
	Computational and Applied Mathematics (27.0304)
	Mathematical Biology (27.0306)
	Advanced Statistics, Regression, ANOVA, Path Analysis and/or Statistical Models (27.0598)
	Advanced Mathematics Topics, Abstract Algebra, Advanced Analysis, Game Theory, Modern Algebra Structures, Real Analysis, Advanced Calculus, Vector Analysis, History of Mathematics/Fourier Analysis (27.9994)
	Calculus I, Calculus II, Calculus III, Calculus IV, Calculus for Life Science, Calculus for Economics, Calculus for Business, Calculus for Technology, Applied Calculus, Calculus for Decision-Making, Survey of Calculus and (27.9995)
	Engineering Mathematics, Engineering Statistics, Engineering Computations, Engineering Analysis (14.9995)
Science	Animal Sciences, General (01.0901)
	Agricultural Animal Breeding (01.0902)
	Animal Health (01.0903)
	Animal Nutrition (01.0904)
	Dairy Science (01.0905)

STEM course category used in the study	Specific course (CIP code[a]) in BPS:04/09
Science—cont.	Livestock Management (01.0906)
	Poultry Science (01.0907)
	Anatomy of Domestic Animals, Physiology of Domestic Animals and/or Animal Growth (01.0998)
	Animal Sciences, Other (01.0999)
	Food Science (01.1001)
	Food Technology and Processing (01.1002)
	Food Science and Technology, Other (01.1099)
	Plant Sciences, General (01.1101)
	Agronomy and Crop Science (01.1102)
	Horticultural Science (01.1103)
	Agricultural and Horticultural Plant Breeding (01.1104)
	Plant Protection & Integrated Pest Management (01.1105)
	Range Science and Management (01.1106)
	Horticultural Botany, Plant Propagation and/or Plant Nutrition (01.1198)
	Plant Sciences, Other (01.1199)
	Soil Science and Agronomy, General (01.1201)
	Soil Chemistry and Physics (01.1202)
	Soil Microbiology (01.1203)
	Soil Sciences, Other (01.1299)
	Biological and Biomedical Sciences (26.0001 to 26.9999)
	Physical sciences (40.0000 to 40.9999)
	Biological and Physical Sciences (30.0101)
	Systems Science and Theory (30.0601)
	Biopsychology (30.1001)
	Natural Sciences (30.1801)
	Cognitive Science (30.2501)
	Human Biology (30.2701)
	Marine Sciences (30.3201)
	Physiological Psychology/Psychobiology (42.2706)
Computer and information sciences	Computer and Information Sciences, General (11.0101)
	Artificial Intelligence (11.0102)
	Information Technology (11.0103)
	Informatics (11.0104)
	Computer Logic and/or Digital Logic (11.0198)
	Computer and information Science, Other (11.0199)
	Computer Programming/Programmer, General (11.0201)
	Computer Programming, Specific Applications (11.0202)
	Computer Programming, Vendor/Product Certification (11.0203)
	COBOL, FORTRAN and/or C Language (11.0295)

STEM course category used in the study	Specific course (CIP code[a]) in BPS:04/09
Computer and information sciences—cont.	Object-Oriented Programming Languages (JAVA, C++, VisualBasic) (11.0297) Machine Language, Assembler Language, Compiler Language, Grammar, Program Language Theory, Language Processing and/or Formal Language (11.0298) Computer Programming, Other (11.0299) Data Processing and Data Processing Technology (11.0301) Information Science/Studies (11.0401) Computer Systems Analyst/Analysis (11.0501) Data Entry/Microcomputer Applications, General (11.0601) Word Processing (11.0602) Data Entry/Microcomputer Applications (11.0693) Statistical Packages, SAS, SPSS, STATA, etc. (11.0694) Computer applications for social sciences (11.0695) Data entry/computer applications for specialized service industries (11.0696) Data entry/computer applications for General Business, General Office (11.0697) Presentation Graphics, Spreadsheet and/or Data Base (11.0698) Data Entry/Microcomputer Applications, Other (11.0699) Computer Science (11.0701) Introduction to Digital Computers (11.0798) Computer Software and Media Applications, General (11.0800) Web Page, Digital/Multimedia and Information Resources Design (11.0801) Data Modeling/Warehousing and Database Administration (11.0802) Computer Graphics (11.0803) Modeling, Virtual Environments and Simulation (11.0804) Computer Software and Media Applications, Other (11.0899) Computer Systems Networking and Telecommunications (11.0901) Computer Lab (11.0997) E-Learning Design and/or Computer Instructional Design (11.0998) Computer/Information Technology Administration and Management, General (11.1000) Network and System Administration (11.1001) System, Networking, LAN/WAN Management (11.1002) Computer and Information Systems Security/Information Assurance (11.1003)

STEM course category used in the study	Specific course (CIP code[a]) in BPS:04/09
Computer and information sciences—cont.	Web/Multimedia Management and Webmaster (11.1004) Information Technology Project Management (11.1005) Computer Support Specialist (11.1006) Computer/Information Technology Services Administration and Management, Other (11.1099) Computer and Information Sciences and Support Services, Other (11.9999) Computer Applications in Engineering (14.9998) Mathematics and Computer Science (30.0801) Accounting and Computer Science (30.1601)
Engineering and technologies	Engineering (14.0101 to 14.9999) Engineering Technologies (15.0000 to 15.0500, 15.0502 to 15.9999) Science and Technologies (41.0000 to 41.9999)

[a] Course codes based on the 2000 edition of Classification of Instructional Programs (CIP) appear in parentheses (http://nces.ed.gov/pubs2002/cip2000/ciplist.asp).

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