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What's Known

Exploring the foundations of the future STEM workforce: K–12 indicators of postsecondary STEM success

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Key findings

This review of research on K–12 indicators that are significant predictors of students' postsecondary science, technology, engineering, and math (STEM) success, specifically for Hispanic students, finds that:

- High school math and science courses taken, the level of those courses, and interest or confidence in STEM at the K–12 level predict postsecondary STEM success for students of all racial/ethnic backgrounds.
- Racial/ethnic minority students, including Hispanic students, take fewer high-level high school math and science courses than White students but have similar interest in STEM.

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Summary

The number of jobs in science, technology, engineering, and math (STEM) is growing rapidly and is expected to increase by approximately 1 million in the United States between 2012 and 2022 (Vilorio, 2014). But people of many racial/ethnic minorities, including Hispanic people, are underrepresented among recipients of STEM degrees and among employees in STEM fields (Beede et al., 2011). Regional Educational Laboratory Southwest conducted this review of the research literature to identify malleable factors that can be measured in K–12 settings and that predict students' postsecondary STEM success (defined as enrolling in, persisting in, and completing a postsecondary STEM major or degree), particularly for Hispanic students. Identifying these predictive malleable factors can help policymakers and district and school administrators develop and implement interventions that increase the percentage of Hispanic students succeeding in postsecondary STEM majors and pursuing STEM careers.

Key findings from the literature review include:

- The number of high school math and science courses taken and the level of those courses predict postsecondary STEM success for all student subgroups. But racial/ethnic minority students were less likely than White students to take the highest level math and science courses.
- Interest or confidence in STEM showed statistically significant predictive relationships with students' postsecondary STEM success, and the relationships were evident as early as middle school. Racial/ethnic minority and White students had similar interest and confidence in STEM.
- Indicators related to achievement in middle school and high school predicted students' postsecondary STEM success. Examples are high school grade point average, class rank, math and science achievement, and SAT Reasoning Test or ACT math scores. Grades in math and science courses were less predictive of postsecondary STEM success for racial/ethnic minority students, including Hispanic students, than for White students.
- Statistically significant high school predictors of postsecondary STEM success included schools' academic rigor, percentage of students enrolled in college preparatory programs, students' satisfaction with their teachers, and levels of parent participation.
- Few studies examined K–12 predictors of postsecondary STEM success specifically for Hispanic students. Four of the 23 studies presented results at a level that enabled the relationship between K–12 indicators and postsecondary STEM success to be compared between Hispanic and non-Hispanic students. Three additional studies compared indicator strength of prediction for racial/ethnic minority students (Hispanic students were grouped together with other non-Hispanic racial/ethnic minority students) versus non–racial/ethnic minority students.

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Why this review?

Members of the Texas Hispanic STEM Research Alliance, who work in school districts, state education agencies and resource centers, and institutes of higher education across the state, share a common goal of improving outcomes for Hispanic students. As a group, the alliance has expressed concern about the low number of Hispanic students enrolling and persisting in advanced STEM courses at the K–12 level and pursuing and completing STEM postsecondary degrees. In Texas, Hispanic students account for more than 51 percent of the student population and make up the entire student body in some geographic regions.

This report is intended to inform the alliance's research and technical assistance agenda by reviewing what is currently known in the field about K–12 predictors of postsecondary STEM outcomes, particularly for Hispanic students. By scanning the current research landscape, this report can serve as an initial step toward developing interventions that improve Hispanic students' ability and motivation to pursue STEM-related degrees and careers. Results from this review can be used to inform future research and programmatic decisions at the state and local levels, so that Hispanic students may experience greater opportunity and achievement in STEM fields.

This report can serve as an initial step toward developing interventions that improve Hispanic students' ability and motivation to pursue STEM-related degrees and careers

Hispanic people are underrepresented in STEM careers

With considerable shifts in the demographic composition of the United States, an increasing share of the national pool of potential STEM workers is—and will continue to be—composed of racial/ethnic minority populations. But people of many racial/ethnic minorities, including Hispanic people, are underrepresented among employees in STEM fields. In 2009 Hispanic employees accounted for 14 percent of the workforce but held just 6 percent of STEM jobs (Beede et al., 2011).

Racial/ethnic minority participation in STEM careers is a concern both in terms of the sustainability of the STEM workforce and in terms of equitable opportunities. In addition to being a growing segment of the economy, jobs in STEM fields command wages that average 26 percent higher than those for jobs in non-STEM fields (Langdon, McKittrick, Beede, Khan, & Doms, 2011).

Hispanic students are less likely to pursue postsecondary education

Because STEM careers typically demand greater educational attainment than non-STEM careers, the underrepresentation of Hispanic people in the STEM workforce may be explained in part by differences in the STEM knowledge, skills, and motivation that are instilled into Hispanic students in grades K–12. Much research has explored the underlying causes of disparities in educational attainment between racial/ethnic minority students, including Hispanic students, and non–racial/ethnic minority students. The causes include fewer resources and a lack of highly qualified teachers in schools with larger racial/ethnic minority populations (Adelman, 2006; Flores, 2007; National Science Foundation, 2010), differences in teacher expectations for racial/ethnic minority students and White students (Fergus, 2009), and underrepresentation of racial/ethnic minority students in high-level courses, which present students with more challenging and complex instruction and disproportionate access to rigorous, high-quality education (Adelman, 2006;

Bonous-Hammarth, 2006; Gamoran, Porter, Smithson, & White, 1997; May & Chubin, 2003; Oakes, 1990, 1995).

The disparities in Hispanic students' education experiences have consequences for their likelihood of pursuing a STEM degree and for their career options later in life. Although Hispanic students' high school dropout rate has fallen from 28 percent to 14 percent in recent years, it remains twice as high as that of White students (Fry & Taylor, 2013). Hispanic high school graduates are more likely than White students to attend a community college, where they may be less likely to pursue a STEM major (Crisp & Nora, 2012; Pew Hispanic Center, 2005), and Hispanic students' persistence in postsecondary STEM education is lower than that of White students (Higher Education Research Institute, 2010).

The combination of economic promise from STEM careers and underrepresentation of Hispanic students earning the degrees needed to gain employment in STEM fields has spurred policymakers' interest in interventions to improve Hispanic students' ability and motivation to pursue a STEM career. The Texas Hispanic STEM Research Alliance—whose members include representatives from the American STEM Alliance, the Texas Valley Community Foundation, and the Texas Higher Education Coordinating Board; STEM coordinators at three Education Service Centers and two high schools; and faculty and staff at five major universities—has expressed concerns about the low number of Hispanic students enrolling in STEM courses in higher education and receiving a STEM degree.

The combination of economic promise from STEM careers and underrepresentation of Hispanic students earning the degrees needed to gain employment in STEM fields has spurred interest in interventions to improve Hispanic students' motivation to pursue a STEM career

Identifying malleable K–12 factors that predict postsecondary STEM success can inform the development of interventions

A first step in developing effective educational interventions for all students—and for Hispanic students in particular—is for researchers and policymakers to identify leading indicators, factors that are both malleable and predictive, of a desired or undesired education outcome (Neild, Balfanz, & Herzog, 2007). These indicators, although not necessarily causally related to education outcomes, provide guidance on what factors may play a role in later education outcomes. By identifying indicators, particularly ones that are actionable at the school or district level, interventions may be designed and targeted, and the results studied, to provide evidence of a causal impact. For example, if taking algebra in grade 8 is an indicator of postsecondary STEM success, schools or districts may want to implement policies or programs that encourage students to take algebra early. Such a policy change should then be studied to provide causal evidence of the impact of early algebra taking on later postsecondary STEM success.

However, key indicators may not always predict outcomes of interest to the same extent across groups defined by race/ethnicity and language proficiency (Camara & Echternacht, 2000; Hoffman & Lowitzki, 2005; Zwick & Sklar, 2005). Thus, it is important to examine ways in which such indicators may be more predictive for various subgroups of students.

What the study examined

The goals of this review of existing research are to identify K–12 indicators of students' postsecondary STEM success (defined as enrolling in, persisting in, and completing a postsecondary STEM major or degree) and to consider the evidence of whether such indicators are the same or different for Hispanic students.

This report addresses two research questions:

- What K–12 indicators predict postsecondary STEM success?
- To what extent do K–12 indicators of postsecondary STEM success differ for Hispanic and non-Hispanic students?

Consistent with the definitions in National Center for Education Statistics (2011), STEM fields are defined here as majors in computer and information sciences, engineering and engineering technologies, biological and biomedical sciences, math and statistics, physical sciences, and science technologies. This review was systematic and comprehensive; box 1 summarizes the methodology, and appendix A provides more information on how the review was conducted.

This review was systematic and comprehensive

Box 1. Methodology

The review was conducted in four phases. The first was developing criteria for including and excluding research studies. The second was searching for published empirical research studies on postsecondary science, technology, engineering, and math (STEM) success (defined as enrolling in, persisting in, and completing a postsecondary STEM degree). The third was screening the study abstracts and research studies using the criteria developed in the first step. The fourth was summarizing the findings of the studies that addressed the topic.

The review team defined relevant studies as those that:

- Were published in 2000 or later.
- Were conducted in the United States.
- Were published in a peer-reviewed journal.
- Conducted primary research.
- Included at least one K–12 indicator of postsecondary STEM success.
- Included at least one postsecondary STEM outcome.

The review team used a list of keywords to search for studies in databases containing citations and abstracts of studies published in major journals (see appendix A). The search identified 600 journal studies. The review team screened each study's abstract against the review criteria and removed 557 studies because they did not pass the criteria for inclusion.

Of the 43 remaining studies, 20 were excluded in the third step because they were judged to not be relevant to the two research questions for such reasons as samples were not generalizable (for example, highly mathematically gifted children) or the focus was outside the scope of the review (for example, changes over time in female students' interest in math).

Twenty-one studies were judged to have addressed one of the review's two research questions. Two additional studies included in the review examined the relationship between K–12 indicators and STEM careers rather than enrollment in, persistence in, and completion of a postsecondary STEM degree. The two studies were included because the STEM careers used as the outcome in the two studies would require a postsecondary STEM degree in the vast majority of cases and the review team felt that a STEM career served as a proxy for completing a postsecondary STEM degree and because the studies spoke to the underrepresentation of Hispanic people in the STEM workforce (a problem identified by the Hispanic STEM Research

(continued)

Box 1. Methodology *(continued)*

Alliance) and identified K–12 predictors of STEM success more broadly. (See appendix B for author-supplied abstracts of the studies included in the review.)

Of the 23 studies included in the review, 22 were correlational.[1] As such, they examined relationships between K–12 indicators and postsecondary STEM success but contained no information on the causal role of the indicators on the outcomes.

The studies included in the review considered multiple indicators of postsecondary STEM success concurrently and used different methodologies, samples, and definitions of subgroups of interest (see appendixes A, B, and C for more details about the sample of studies in this review).

Almost all studies included in the review were based on a sample of students who were already enrolled (or had previously been enrolled) in a four-year college and, in some cases, had declared a major (two studies—Wang [2013a, 2013b]—included students enrolled in two-year colleges, and two studies—Ing & Nylund-Gibson [2013] and Miller & Kimmel [2012]—examined STEM careers and thus were not limited to students enrolled in postsecondary education). This is in part a consequence of the retrospective design of much longitudinal education research: starting with students who have enrolled in college and therefore have data on the outcomes of interest is more feasible and less costly than following a cohort of students forward in time who may or may not persist in the study, enter college, and have data available on the outcomes of interest. Furthermore, it is a result of conditioning many of the outcomes examined on enrolling in postsecondary education (that is, students can major in, persist in, and complete a degree in a STEM major only if they enroll in postsecondary education first). The limitations of interpretation resulting from this design are discussed in the limitations section of the report.

Because many of the studies that examined racial/ethnic differences in postsecondary STEM success also examined differences by gender, findings related to gender differences were included when appropriate.

Note

1. One study analyzed data that had been collected as part of an experimental study designed for another purpose. The authors followed up with students approximately 12 years after that study; however, it was not the initial intent of the original study to examine postsecondary success for participating students.

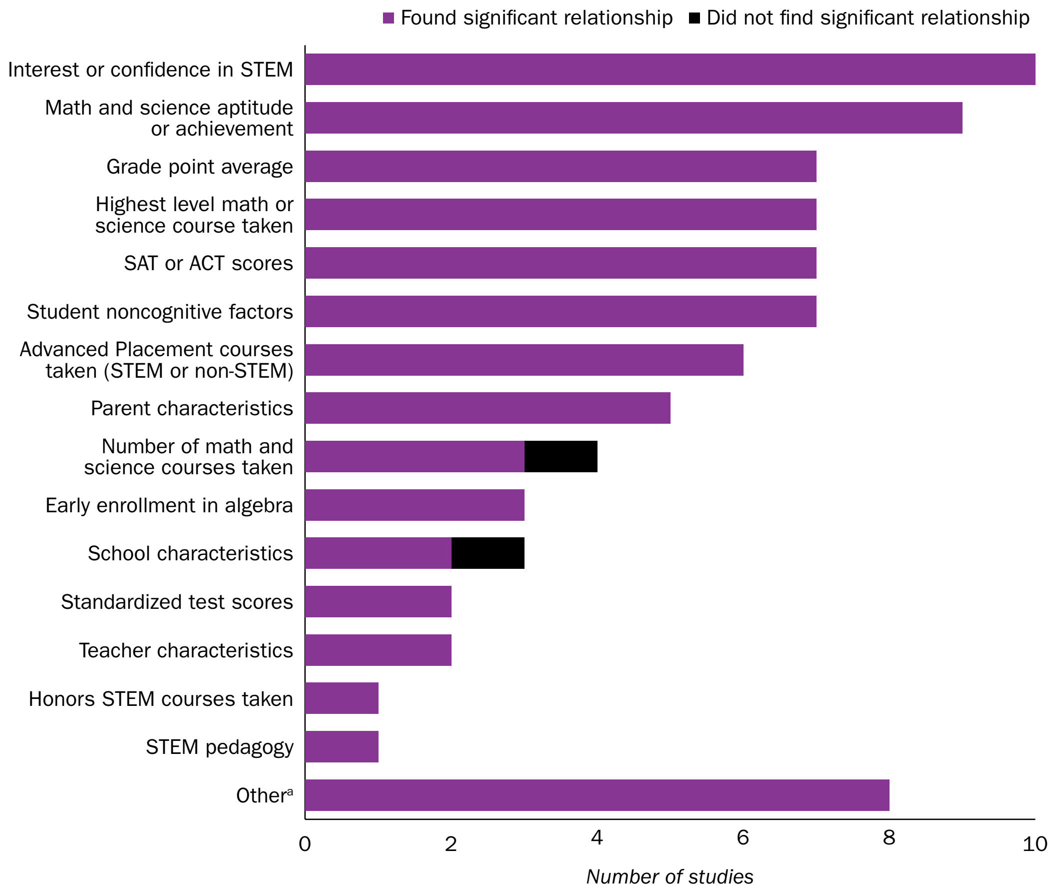
What the review found

This section details the findings on K–12 indicators of students' postsecondary STEM success and the differences in those indicators between Hispanic and non-Hispanic students.

Courses taken in high school, interest or confidence in STEM, and achievement are the most frequently examined types of indicators of students' postsecondary STEM success

The most frequently examined indicators of postsecondary STEM success were measures of courses taken in high school (15 studies in total across five indicators, some of which included multiple subindicators). Specific indicators in this category include highest level math or science course taken (7 studies), Advanced Placement courses taken (both STEM and non-STEM, 6 studies), number of math and science courses taken (4 studies), early enrollment in algebra (3 studies), and honors math or science courses taken (1 study; figure 1). The second most examined potential indicator was student interest or confidence in

Figure 1. The most frequently examined indicators of postsecondary STEM success were measures of courses taken in high school, followed by student interest or confidence in STEM



STEM is science, technology, engineering, and math.

Note: *n* = 23. Some studies include multiple indicators.

a. Includes class size, math curriculum, extracurricular STEM club participation, science fair participation, high school class rank, and specific measures of student attitudes toward math and science.

Source: Authors' compilation based on the studies reviewed.

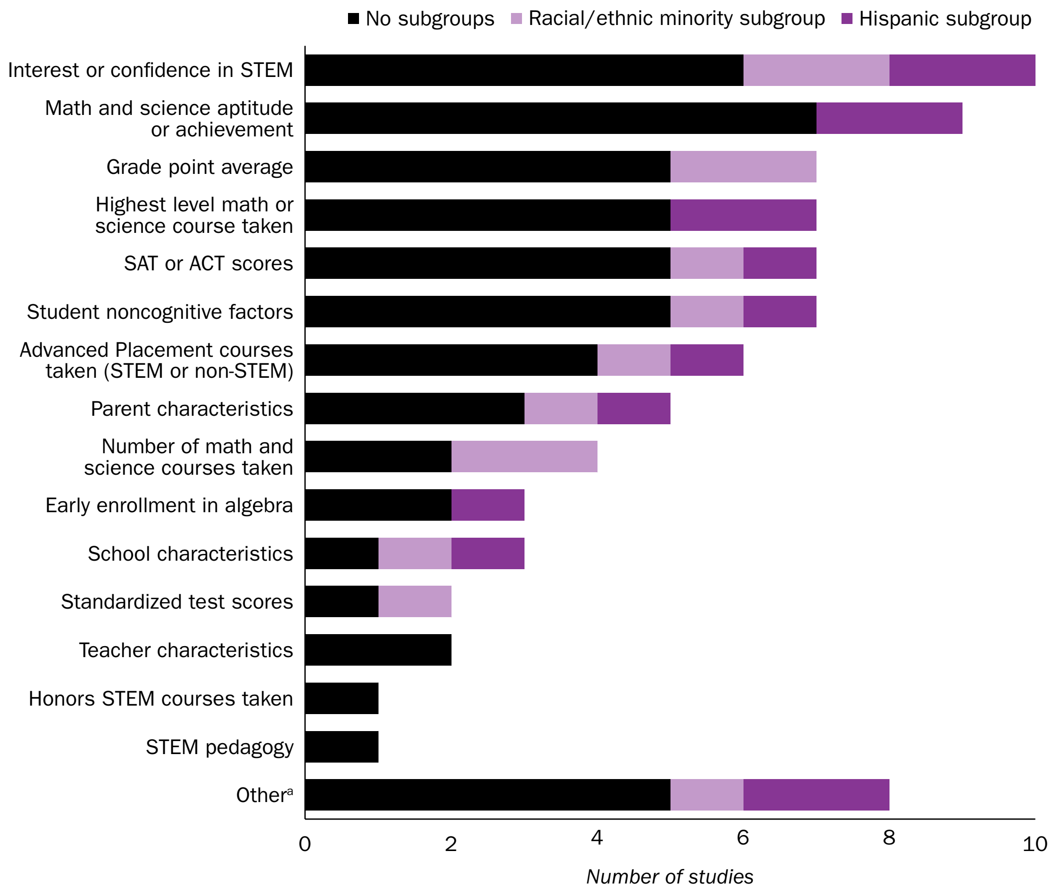
STEM (10 studies). Other examined indicators included math and science aptitude or achievement (9 studies), grade point average (7 studies), SAT or ACT scores (7 studies), student noncognitive factors (including student non-STEM attitudes, 7 studies), school- or teacher-level variables (6 studies total: 3 school characteristics, 2 teacher characteristics, and 1 STEM pedagogy), parent characteristics (5 studies), and standardized test scores (2 studies).

The most frequently examined indicators of postsecondary STEM success were measures of courses taken in high school (15 studies)

Few studies focus on K–12 indicators of postsecondary STEM success for racial/ethnic minority students or Hispanic students in particular

Four of the 23 studies presented results at a level that enabled the relationship between K–12 indicators and postsecondary STEM success to be compared between Hispanic and non-Hispanic students (that is, subgroup analyses or interactions between indicators and race/ethnicity were conducted; figure 2). Three additional studies compared indicator

Figure 2. Few studies focus on K–12 indicators of postsecondary STEM success for racial/ethnic minority students or Hispanic students in particular



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a. Includes class size, math curriculum, extracurricular STEM club participation, science fair participation, high school class rank, and specific measures of student attitudes toward math and science.

Source: Authors' compilation based on the studies reviewed.

strength of prediction for racial/ethnic minority versus non–racial/ethnic minority students, but Hispanic students were grouped together with other non-Hispanic racial/ethnic minority students.

Taking more and high-level math and science courses predicts postsecondary STEM success

The most common K–12 indicators found to be statistically significant predictors of postsecondary STEM success were measures related to high school math and science courses taken (for example, highest level math course taken, Advanced Placement STEM courses taken, early enrollment in algebra). Fifteen of the 23 studies examined some measure of high school math and science course taking; of these 15 studies, 14 found a significant positive relationship, and 1—which examined number of math and science courses taken—found no relationship. In studies that included the highest level math and science course taken as one of multiple potential indicators, it consistently emerged as most predictive of postsecondary STEM success (that is, had the largest coefficients, standardized effect sizes, or odds ratios).

Of the 15 studies that examined the relationship between high school math or science courses taken and postsecondary STEM success, 10 were longitudinal studies that used a nationally representative sample of students and took measurements over time (Burge, 2013; Engberg & Wolniak, 2013; Griffith, 2010; Ma, 2011; Maltese & Tai, 2011; Miller & Kimmel, 2012; Riegle-Crumb & King, 2010; Wang, 2013a, 2013b; You, 2013; table 1). An additional five were retrospective studies that relied on samples of students enrolled at selected postsecondary institutions (Ackerman, Kanfer, & Calderwood, 2013; Espinosa, 2011; Kokkelenberg & Sinha, 2010; Shaw & Barbuti, 2010; Tyson, Lee, Borman, & Hanson, 2007).

All seven studies that examined the relationship between the highest level math or science course taken and postsecondary STEM success found a statistically significant positive relationship

All seven studies that examined the relationship between the highest level math or science course taken and postsecondary STEM success found a statistically significant positive relationship (Engberg & Wolniak, 2013; Ma, 2011; Maltese & Tai, 2011; Miller & Kimmel, 2012; Riegle-Crumb & King, 2010; Tyson et al., 2007; You, 2013). Three studies found that students who took more math and science courses in high school had more positive postsecondary STEM outcomes (Burge, 2013; Wang, 2013a, 2013b), and one did not find a statistically significant relationship (Espinosa, 2011). Advanced Placement STEM courses taken (Ackerman et al., 2013; Griffith, 2010; Kokkelenberg & Sinha, 2010; Shaw & Barbuti, 2010; Tyson et al., 2007; You, 2013), early enrollment in algebra (Maltese & Tai, 2011; Miller & Kimmel, 2012; You, 2013), and honors math or science courses taken (Tyson et al., 2007) were also found to be associated with greater postsecondary STEM success.

Of the 15 studies that examined the relationship between high school science and math courses taken and postsecondary STEM success, 5 examined whether the relationship between the predictor and outcome differed by race/ethnicity, sometimes specifically looking at the Hispanic student subgroup, sometimes not. Two of the studies looked at differences in the relationship between the number of math and science courses taken and

Table 1. Longitudinal and retrospective studies examining math and science courses taken as indicators of postsecondary STEM success

Indicator	Longitudinal studies	Retrospective studies
Highest level math or science course taken	Engberg & Wolniak, 2013; Ma, 2011; Maltese & Tai, 2011; Miller & Kimmel, 2012; Riegle-Crumb & King, 2010; You, 2013	Tyson et al., 2007
Number of math and science courses taken	Burge, 2013; Wang, 2013a; Wang, 2013b	Espinosa, 2011
Advanced Placement STEM courses taken	Griffith, 2010; You, 2013	Ackerman et al., 2013; Kokkelenberg & Sinha, 2010; Shaw & Barbuti, 2010; Tyson et al., 2007
Early enrollment in algebra	Maltese & Tai, 2011; Miller & Kimmel, 2012; You, 2013	
Honors math or science courses taken		Tyson et al., 2007

STEM is science, technology, engineering, and math.

Source: Authors' compilation.

postsecondary STEM success (Espinosa, 2011; Wang, 2013b). The remaining three looked at differences in the relationship between the level of math and science courses taken and postsecondary STEM success (Griffith, 2010; Riegle-Crumb & King, 2010; You, 2013).

The relationship between the number of math and science courses taken and postsecondary STEM success differed by race/ethnicity. Using nationally representative survey data from the 2002 Education Longitudinal Study, which contains survey data from the same cohort of students measured three times over a four-year period (every two years), Wang (2013b) found that for students overall the number of math and science courses taken during high school was the strongest predictor (that is, had a statistically significantly larger standardized coefficient than all other predictors in the model) of pursuing a STEM major. However, when subgroups were examined the indicator performed strongest for White students and weakest for underrepresented racial/ethnic minority students (Hispanic, Black, and Native American students; Asian students were not included because of their overrepresentation in higher education and STEM majors). Espinosa (2011) looked at outcomes for women only and found that years of math, physical science, and biological science were not predictive of persisting in a STEM major for either White women or racial/ethnic minority women (of which 37 percent were Hispanic).

The relationship between the highest level math and science course taken and postsecondary STEM success was strong and did not differ by race/ethnicity

The relationship between the highest level math and science course taken and postsecondary STEM success was strong and did not differ by race/ethnicity. You (2013) and Riegle-Crumb & King (2010) also used data from the 2002 Education Longitudinal Study to examine the highest level math and science course taken (both studies included measures of math and science achievement, attitudes toward math and science, parent attitudes, and school characteristics in predictive models). Both studies found that the highest level math and science course taken in high school—in particular, having taken calculus, according to You (2013)—was most predictive (that is, had the greatest odds ratio coefficient, which was statistically significantly larger than other coefficients in the model) of pursuing a postsecondary STEM major. The finding was similar for students of all races/ethnicities and genders in both studies. The number of math and science courses taken was more predictive of postsecondary STEM success for White students when the level of the course was not considered, but the rigor of the highest level course taken predicted postsecondary STEM success for all student subgroups. Additionally, Griffith (2010) found that Advanced Placement STEM courses taken, in particular, were the strongest predictor (that is had the largest coefficient, which was statistically significantly larger than other coefficients in the model) of postsecondary STEM success for racial/ethnic minority (but not White) students.

Disparities in the highest level math and science course taken are related to postsecondary disparities in STEM success. Despite finding that the level of math and science courses taken was similarly predictive of pursuing a STEM major for all races/ethnicities and genders, You (2013) found that Hispanic and Black students received more high school math credits than White students but that those credits were in lower level courses. Thus, while Black and Hispanic students were generally less likely to take higher level courses, those who did take higher level courses were just as likely to pursue a STEM major as their White counterparts (Riegle-Crumb & King, 2010; Tyson et al., 2007; You, 2013).

Interest or confidence in STEM predicts postsecondary STEM success

The second most identified category of significant K–12 predictors of postsecondary STEM success in the reviewed studies was measures of students' reported interest or confidence in STEM. All studies that examined the relationship between interest or confidence in STEM and postsecondary STEM success found a statistically significant positive relationship, though the specific measures used were based on survey responses and differed across studies.

Both studies in the review that examined early interest in STEM found that interest in STEM, when measured in middle or junior high school, was an indicator of postsecondary and career STEM success (Ing & Nylund-Gibson, 2013; Maltese & Tai, 2011). Grade 8 students who indicated that they were interested in a science career and grade 8 students who believed that science would be useful in their future were more likely to complete a STEM degree, even among students who had similar course-taking patterns, grades, and interests later in high school (Maltese & Tai, 2011). Grade 7 students who were classified as having the most positive attitudes toward math and science based on a series of survey questions were also the most likely to be in a STEM profession 20 years later (Ing & Nylund-Gibson, 2013). Many of these studies measured interest or confidence in STEM during high school, as well as STEM courses taken in high school. Although all studies that measured these predictors simultaneously found that each one was predictive of postsecondary STEM success, measures of interest or confidence were consistently less predictive of later STEM outcomes (that is, had smaller coefficients, standardized effect sizes, or odds ratios) than courses taken were (Engberg & Wolniak, 2013; Ma, 2011; Maltese & Tai, 2011; Miller & Kimmel, 2012; Riegle-Crumb & King, 2010; Wang, 2013b; You, 2013).

Early interest in STEM, when measured in middle or junior high school, was an indicator of postsecondary and career STEM success

Racial/ethnic minority and female students are less likely to achieve postsecondary STEM success despite similarly positive dispositions toward math and science. Three studies examined whether K–12 interest in STEM differed by student subgroup. Ing & Nylund-Gibson (2013) found that racial/ethnic minority (including Hispanic) and female students were more likely to be classified into the group of students with the most positive attitudes toward math and science but far less likely to be in a STEM career as an adult. You (2013) and Riegle-Crumb & King (2010) found that racial/ethnic minority high school students (including Hispanic students) had positive attitudes toward math and science and confidence in math similar to those of White students but a lower rate of pursuing a STEM major. While attitudes were predictive of pursuing a STEM major for both White and racial/ethnic minority students, racial/ethnic minority students pursue a STEM major at a far lower rate than White students with similar attitudes toward math and science. Together, these studies suggest that although the relationship between interest in STEM in grades K–12 and postsecondary STEM success is similar between racial/ethnic minority students and White students and between male students and female students, at all levels of interest racial/ethnic minority students and female students are less likely to pursue a STEM major.

Overall K–12 achievement predicts postsecondary STEM achievement

Various indicators of high school achievement, including high school grade point average (Ackerman et al., 2013; Engberg & Wolniak, 2013; Espinosa, 2011; Griffith, 2010; Kokkelenberg & Sinha, 2010; Rohr, 2012; Shaw & Barbuti, 2010), class rank (indicator classified as “other”; Crisp, Nora, & Taggart, 2009; Thompson & Bolin, 2011), and high school math and science achievement (Harwell, Medhanie, Post, Norman, & Dupuis, 2012; Maltese & Tai, 2011; Miller & Kimmel, 2012; Nicholls, Wolfe, Besterfield-Sacre, & Shuman, 2010; Riegle-Crumb & King, 2010; Shaw & Barbuti, 2010; Wang, 2013a, 2013b; You, 2013), were also found to be indicators of postsecondary STEM success. However, achievement cannot be divorced from interest or confidence or courses taken. Maltese and Tai (2011) found that math and science achievement in grade 10 was predictive of math and science attitudes and motivation in grade 12, which in turn was predictive of postsecondary STEM success.

In addition to finding that the number of math and science courses taken was less predictive of pursuing a STEM major for racial/ethnic minority students than for White students, You (2013) also found that grades in math and science courses taken in high school were less predictive of pursuing a STEM major for racial/ethnic minority students than for White students. Again, differences in the average rigor of the courses taken between racial/ethnic minority and White students (shown by You [2013]) may help explain this finding.

Seven studies found that students with higher SAT or ACT math scores were more likely to achieve postsecondary STEM success

SAT and ACT math scores predict postsecondary STEM success

Seven studies examined whether SAT math scores predict postsecondary STEM success. All found that students with higher SAT or ACT math scores were more likely to achieve postsecondary STEM success (Ackerman et al., 2013; Crisp et al., 2009; Griffith, 2010; Harwell et al., 2012; Kokkelenberg & Sinha, 2010; Nicholls et al., 2010; Rohr, 2012). No studies examined differences in the relationship between SAT scores and postsecondary STEM outcomes separately for Hispanic or racial/ethnic minority students.

Non-STEM courses taken and ability are negatively related to pursuing a STEM degree when math and science achievement is held constant

Four studies provide evidence that non-STEM interests and skills are also related to postsecondary STEM outcomes (two studies classified as “SAT or ACT” and two studies classified as “Advanced Placement courses taken”). Unlike SAT math scores, SAT and ACT verbal (English) scores were found to be negatively related to completing a postsecondary STEM degree (Kokkelenberg & Sinha, 2010; Nicholls et al., 2010). That is, for students with the same SAT or ACT math score, the higher their verbal score, the less likely it was that they would pursue or complete a postsecondary STEM degree. Furthermore, Griffith (2010) and Kokkelenberg and Sinha (2010) found that holding the number of Advanced Placement STEM courses taken constant, the percentage and number of Advanced Placement non-STEM courses taken in high school (for example, Advanced Placement English or Advanced Placement History) were negatively related to pursuing a STEM major and completing a STEM degree. Thus, if two students have similar math ability or achievement, but one has greater verbal ability or achievement, the student with greater verbal ability or achievement is less likely to pursue a STEM major. No studies examined whether these indicators performed differently for Hispanic students as compared with non-Hispanic or White students.

School-, classroom-, and teacher-level characteristics showed mixed relationships with postsecondary STEM success

Two studies used longitudinal survey data from a nationally representative sample of students to examine whether characteristics of their high schools, such as the proportion of students enrolled in college preparatory programs or students' satisfaction with their teachers, were significant predictors of postsecondary STEM success. Results were mixed. Engberg and Wolniak (2013) found that the extent to which students received academic and career guidance, the proportion of students enrolled in a college preparatory program, and student ratings of the school's overall learning environment (that is, the extent to which learning was hindered by the lack of computers, multimedia, science labs, library, and so on) were not associated with pursuing a STEM major. By contrast, You (2013) found that the proportion of students in a school who were enrolled in a college preparatory program, students' perceptions of how academically demanding their school was, the degree to which students were satisfied with their teachers, and the average level of parents' participation in their student's education were all associated with pursuing a STEM major.

Being in a small class was found to increase the rate of completing a STEM degree: from 1.0 percent of students in the control group to 2.4 percent of students in the treatment group

Two studies examined whether teacher attitudes and practices were predictors of postsecondary STEM success. Students who reported that their math teacher used hands-on materials were more likely to complete a STEM degree, while those who reported that they frequently used computers were less likely. In science, students who reported that their teachers emphasized further study in science were more likely to complete a STEM degree, while those who reported more frequent lecturing by their teacher and more frequent use of books to indicate how experiments should be run were less likely (Maltese & Tai, 2011). Encouragement from a science or math teacher was not found to be a significant predictor of postsecondary STEM success (Miller & Kimmel, 2012).

One study examining college students who had taken at least two college math courses of a difficulty level at or beyond precalculus found that students performed equally well in those courses regardless of whether their high school used a commercially developed or standards-based (Core-Plus) high school math curriculum (Harwell et al., 2012).

Smaller class size in early grades increased the rate of completing a postsecondary STEM degree. More than a decade after students participated in an experimental study designed to study the impacts of class size, their college enrollment data were examined to explore the potential long-term impacts of being assigned to a small class (13–17 students) from kindergarten through grade 3. Being in a small class was found to increase the rate of completing a STEM degree: from 1.0 percent of students in the control group to 2.4 percent of students in the treatment group (in experimentally controlled smaller classrooms; Dynarski, Hyman, & Schanzenbach, 2013). Though that study was not originally designed to test the impact of class size in early grades on postsecondary outcomes, the follow-up work found a significant relationship more than a decade later.

There is evidence of differential impact of class size by student race/ethnicity and school socioeconomic makeup. No studies explored whether the relationship between school- or classroom-level predictors and postsecondary STEM success differed between Hispanic and non-Hispanic students. But Dynarski et al. (2013) found that the effect of small classrooms most positively affected Black students and students attending poor schools.

Parent attitudes predict postsecondary STEM success

Three studies found that parent attitudes during students' high school years were significantly related to postsecondary STEM success, with parent encouragement of science and math increasing the likelihood of entering a STEM profession (Miller & Kimmel, 2012) and parents' expectations related to the length of their children's education (that is, how far they will go in school) predictive of pursuing a STEM major (Nicholls et al., 2010; You, 2013). No studies explored subgroup differences based on race/ethnicity.

Student non-STEM attitudes are related to postsecondary STEM success

Two studies looked at how student non-STEM attitudes influenced postsecondary STEM success (classified as "student noncognitive factors"). Nicholls et al. (2010) found that high school students who saw themselves going further in school were more likely to pursue a STEM major. Burge (2013) focused on gender differences in attitudes toward family and children, finding that among adolescents with a low priority on parenthood, there was no gender difference in the rate of completing a STEM degree (after academics and background factors were controlled for), but among adolescents who put a high priority on parenthood, men were three times more likely than women to complete a STEM degree (indicator classified as "other"). No studies explored subgroup differences based on race/ethnicity.

Extracurricular activities predict postsecondary STEM success

The one study that examined participation in STEM extracurricular activities (indicator classified as "other") found that such activities significantly predicted postsecondary STEM success. Specifically, Gottfried and Williams (2013) examined the relationship between math club and science club participation and pursuing a STEM major. They found that participating in a math club but not a science club predicted pursuing a STEM major even after differences between students who did and did not participate in math and science clubs (for example, demographics and prior achievement) were controlled for. These findings were similar for all subgroups of students regardless of race/ethnicity.

Implications of the review findings

The studies in this review have important implications for both research and practice related to preparing students for postsecondary STEM pursuits. However, only one study was able to identify a causal relationship, and no study was specifically designed to determine whether a causal relationship exists between a K–12 indicator and a postsecondary STEM outcome. As such, while the indicators identified as significant were found to be related systematically and meaningfully to postsecondary STEM success, it is unknown whether interventions designed to move a student's position on that indicator (for example, increase his or her grade point average, enroll in additional STEM courses, trigger an early interest in STEM) will have a direct impact on that student's likelihood of enrolling in, persisting in, or completing a STEM major or degree.

While the indicators identified as significant were found to be related systematically and meaningfully to postsecondary STEM success, it is unknown whether interventions designed to move a student's position on that indicator will have a direct impact on the likelihood of enrolling in, persisting in, or completing a STEM major or degree

Taking high-level STEM courses

The reviewed research revealed that taking high-level math and science courses is the strongest indicator of postsecondary STEM success for students of all races/ethnicities.

While the number of math and science courses taken was more predictive of postsecondary STEM success for White students than for Hispanic or other racial/ethnic minority students, additional research showed that Hispanic and other racial/ethnic minority students take lower level math and science courses, on average, than White students do. These racial/ethnic differences in choosing rigorous high-level courses may translate into the racial/ethnic differences in enrolling in, persisting in, and completing a STEM major or degree. Among students who took the highest level math and science courses, there were no postsecondary STEM disparities by race/ethnicity.

If racial/ethnic minority students are taking lower level courses, interventions focused on simply increasing the number of math and science courses they take may be targeting the wrong indicator. Although this research is correlational and not causal, it highlights the possibility that efforts to increase representation of racial/ethnic minority students in high-level math and science courses may be more effective in reducing racial/ethnic disparities in postsecondary STEM success than efforts to increase the number of courses these students take.

Efforts to increase the representation of racial/ethnic minority students in high-level math and science courses may be more effective in reducing racial/ethnic disparities in postsecondary STEM success than efforts to increase the number of courses these students take

While the reviewed research suggests that reducing disparities in math and science preparation between Hispanic and White students and increasing the rates at which Hispanic students take high-level math and science courses have promise for informing interventions designed to improve STEM outcomes, the source of the disparities remains unknown. For instance, it may be that the disparities arise in part because schools serving high proportions of Hispanic students offer fewer high-level math and science courses. Additional research is needed to examine how much of the disparities is a result of lower rates of high-level course uptake among Hispanic students as opposed to fewer high-level course options in schools serving high proportions of Hispanic students. These possibilities lend themselves to different strategies for increasing the rate at which Hispanic students take high-level math and science courses in high school.

Turning interest in STEM into STEM majors

Positive attitudes toward math and science and early interest in STEM were found to be statistically significant predictors of pursuing a STEM major across races/ethnicities and genders. Though differences in these measures helped explain whether a student enrolled or persisted in a STEM major within each subgroup of students examined, they did not explain disparities in postsecondary STEM outcomes between subgroups of students. In fact, despite lower representation among enrollment in STEM majors and degree recipients, racial/ethnic minority and female students scored as high as White and male high school students on measures of attitudes toward math and science and early interest in STEM. More research is needed to explore mechanisms for supporting Hispanic students' interest in STEM and furthering their participation in STEM through completing a postsecondary degree. Research showing that interest in STEM in middle school was significantly related to postsecondary STEM success points to the importance of efforts to engage and support students who already express such interest in early grades and efforts to help sustain those interests during high school.

There is little research examining the predictive power of indicators of postsecondary STEM success for Hispanic students specifically

This review found few studies that examine relationships between indicators and outcomes for Hispanic students, either as a separate group or as part of a larger racial/ethnic minority group. Only 4 of 23 studies specifically examined indicators for Hispanic students. Among those four studies, there was no research that examined differences within Hispanic populations (for example, whether differences exist between Hispanic students who are and are not economically disadvantaged or who have or do not have limited English proficiency). More research on differences by student subgroup and more examination of differences within Hispanic student subgroups will help reveal ways in which K–12 indicators vary in their predictive powers relative to postsecondary STEM success and can inform efforts to increase the number of Hispanic students enrolling in, persisting in, and completing a STEM major or degree and entering a STEM career.

More research is needed on the ways in which K–12 indicators differentially predict postsecondary outcomes when all students are included, even those who drop out of high school or do not enroll in college

Limitations of the review findings

A primary limitation of this study's findings is that, with one exception, all studies reviewed were correlational in nature and as such do not assess causation. It remains unknown whether interventions such as requiring students to take higher level STEM courses in high school, for example, will increase the rates of postsecondary STEM success for those students. Additional research is needed to examine the presence of a causal relationship between identified significant indicators and desired outcomes.

Additionally, as previously mentioned, the vast majority of research included in this review (all but four studies) is based on a sample of students who either were enrolled or had been enrolled in four-year colleges and, in some instances, had declared their majors. Disparities between Hispanic and non-Hispanic students in STEM education and the workforce are in part a result of a breakdown in the education pipeline in which Hispanic students are less likely to graduate high school and less likely to enroll in a four-year college (Pew Hispanic Center, 2005). Studies such as these that examine predictors of STEM majors and completion only among students who enrolled in four-year colleges have, by definition, dropped students who did not graduate or did not enroll in college in the first place. Thus, while the research reviewed found that high levels of math and science coursework in high school were similarly predictive of pursuing a STEM major for Hispanic and non-Hispanic students, the results were driven mostly by samples of students who all enrolled in a four-year college. It may be that taking high levels of math and science coursework is not similarly predictive of attending a four-year college for Hispanic and non-Hispanic students when all students are included, as dropout and college enrollment rates vary by race/ethnicity. More research is needed in this area to further explore the ways in which K–12 indicators differentially predict postsecondary outcomes when all students are included, even those who drop out of high school or do not enroll in college.

Appendix A. About the literature review

This appendix provides further details about the literature review.

Database search

The review team searched nine academic databases—Academic Search Premier, Education Full Text, Education Research Complete, ERIC, JSTOR, Professional Development Collection, Psychology and Behavioral Sciences Collection, PsycINFO, and SocINDEX—for full text academic journal articles published between 2000 and 2014. Search terms were developed to capture studies related to STEM education at both the K–12 and the postsecondary levels and STEM education for Hispanic students in particular. The search terms used for each database were "science, technology, engineering, mathematics," "postsecondary education," "STEM education," "STEM" AND "K–12," "STEM" AND ["parental expectations" OR "teacher expectations" OR "school environment"], "STEM" AND "underrepresented minority," "STEM" AND ["Hispanic" OR "completion" OR "enrollment" OR "persistence"], "STEM" AND ["Hispanic" OR "completion" OR "enrollment" OR "persistence"]. A filter was included to exclude studies on stem cells. Studies were further organized into groups based on the database of origin and the search terms used to find them. Duplicate studies were detected and immediately discarded.

Criteria for inclusion in the literature review

Exactly 600 studies were identified from the search, and each abstract was read and coded by the review team using a short screening protocol. To be included in the review, the research conducted or reported on was required to meet the following criteria:

- Published in 2000 or later.
- Conducted in the United States.
- Published in a peer-reviewed journal.
- Conducted primary research.
- Included at least one K–12 indicator of postsecondary STEM success.
- Included at least one postsecondary STEM outcome.

Fifty-eight studies were identified for final full text review. Full text studies were coded by the review team using a detailed protocol that coded for K–12 indicators, postsecondary STEM outcomes, demographics of the study sample, study design, and years studied; covariates included relevant findings, study limitations, and implications. After a full text review, 15 studies were excluded for failing to meet one or more of the six criteria. Of the 43 studies that passed the criteria for inclusion, 23 were identified as relevant to answering the two research questions. Studies were most commonly identified by the review team as not relevant because the sample population had little applicability to the research questions (for example, the top 1 percent of mathematically gifted students), the focus was outside the scope of the review (for example, changes in the STEM gender gap over time), or the study had a weak or flawed research design (for example, a study that made causal claims of the impact of STEM high schools on pursuing a STEM major by comparing the proportion of students in one STEM high school who pursued a STEM major in college to the national average without including any information on how the data were collected).

Although all studies were reviewed using the same criteria for inclusion, regardless of whether they were quantitative or qualitative, no qualitative studies met all the criteria for inclusion. All but one of the studies identified were correlational in nature. Of the 23 correlational studies, 2 used propensity score matching to help control for selection bias, 15 used regression analysis, including demographic and other control variables in the model (models ranged from including only race/ethnicity and gender as controls to including dozens of longitudinal measures to account for the interrelatedness of independent variables), 2 included simultaneous predictors with no controls for differences in background characteristics, and 3 looked at simple correlations between predictors and outcomes with no additional variables (table A1). One study used a randomized controlled trial to investigate a causal relationship between K–12 indicators and postsecondary STEM outcomes.

Focus on Hispanic students

Although a major focus of this literature review was to identify indicators that may perform differently for Hispanic and non-Hispanic students, only four studies were identified that conducted Hispanic subgroup analyses, thus allowing for comparisons to be made regarding whether the relationship between K–12 indicators and postsecondary STEM outcomes was similar or different for Hispanic students and non-Hispanic students (table A2). Three additional studies conducted subgroup analyses for racial/ethnic minority students (including Hispanic students), thus allowing for comparisons in indicator performance to be made

Table A1. Types of studies examining K–12 education indicators of postsecondary STEM success by methodological approach

Methodological approach	Number of studies (*n* = 23)	Percent
Multivariable regression controlling for background characteristics	15	65.2
Multivariable regression, no controls for background characteristics	2	8.7
Correlational, not controlling for background characteristics	3	13.0
Propensity score matching	2	8.7
Randomized controlled trial	1	4.3

STEM is science, technology, engineering, and math.

Note: Percentages do not sum to 100 because of rounding.

Source: Authors' compilation.

Table A2. Studies examining K–12 education indicators of postsecondary STEM success among Hispanic students by focus

Focus	Number of studies (*n* = 23)	Percent
Indicators analyzed for Hispanic student subgroup	4	17.5
Indicators analyzed for racial/ethnic minority student subgroup	3	13.0
Hispanic race/ethnicity included as independent variable or examined as a correlational variable	11	47.8
No inclusion of Hispanic race/ethnicity	5	21.7

STEM is science, technology, engineering, and math.

Source: Authors' compilation.

for racial/ethnic minority and non–racial/ethnic minority students but not for Hispanic students specifically.

Eleven other studies included Hispanic race/ethnicity as an independent variable. These studies examined the impact of being Hispanic on postsecondary STEM outcomes, used Hispanic race/ethnicity as a background control variable, or examined whether including K–12 indicators as controls mitigated racial/ethnic disparities.

Five studies included no measure of Hispanic race/ethnicity.

Studies identifying K–12 indicators and postsecondary STEM outcomes

K–12 indicators. Fifteen of the 23 studies reviewed examined the relationship between STEM courses taken at the K–12 level and postsecondary STEM outcomes. Among these 15 studies, the most common indicators examined were the highest level math or science course taken and Advanced Placement STEM courses taken (table A3). Interest or confidence in STEM was also examined by 10 studies. Seven of the 23 studies examined whether students' grade point average was predictive of postsecondary STEM outcomes, and seven studies looked at SAT or ACT scores. Most studies examined more than one potential indicator of postsecondary STEM success.

Postsecondary STEM outcomes. Studies reviewed were selected because they examined at least one of three postsecondary STEM outcomes: enrolling in a STEM major, persisting in a STEM major, and completing a postsecondary STEM degree (table A4). Some studies included other measures of postsecondary STEM success, including intent to pursue a STEM major after postsecondary enrollment, grades in upper postsecondary math courses or STEM major courses, and number of semesters to graduate with a postsecondary STEM degree. Two studies examined K–12 education indicators of STEM careers, not postsecondary STEM outcomes. Although those studies did not have an outcome measured at the postsecondary level, they included indicators measured at the K–12 level, and in the vast majority of cases the outcome, STEM employment, would have required a STEM degree, thus the review team decided that in those cases STEM career served as a proxy for completing a postsecondary STEM degree. The studies were also included because the review team determined that they were a valuable addition to the findings because they addressed one of the underlying needs for the literature review: the breakdown in the K–12 education pipeline leading to Hispanic underrepresentation in STEM postsecondary education and STEM careers.

Table A3. Studies examining K–12 education indicators of postsecondary STEM success by leading indicator

Indicator	Number of studies (n = 23)	Percent	Citations
Coursework	15	65.2	Ackerman et al., 2013; Burge, 2013; Engberg & Wolniak, 2013; Espinosa, 2011; Griffith, 2010; Kokkelenberg & Sinha, 2010; Ma, 2011; Maltese & Tai, 2011; Miller & Kimmel, 2012; Riegle-Crumb & King, 2010; Shaw & Barbuti, 2010; Tyson et al., 2007; Wang, 2013a, 2013b; You, 2013
Highest level math or science course taken	7	30.4	Engberg & Wolniak, 2013; Ma, 2011; Maltese & Tai, 2011; Miller & Kimmel, 2012; Riegle-Crumb & King, 2010; Tyson et al., 2007; You, 2013
Advanced Placement courses taken (STEM or non-STEM)	6	26.1	Ackerman et al., 2013; Griffith, 2010; Kokkelenberg & Sinha, 2010; Shaw & Barbuti, 2010; Tyson et al., 2007; You, 2013
Number of math and science courses taken	4	17.4	Burge, 2013; Espinosa, 2011; Wang, 2013a, 2013b
Early enrollment in algebra	3	13.0	Maltese & Tai, 2011; Miller & Kimmel, 2012; You, 2013
Honors math or science courses taken	1	4.3	Tyson et al., 2007
Dual credits awarded	0	0.0	
Interest or confidence in STEM	10	43.5	Engberg & Wolniak, 2013; Griffith, 2010; Ing & Nylund-Gibson, 2013; Maltese & Tai, 2011; Miller & Kimmel, 2012; Riegle-Crumb & King, 2010; Shaw & Barbuti, 2010; Wang, 2013a, 2013b; You, 2013
Math and science aptitude or achievement	9	34.8	Burge, 2013; Harwell et al., 2012; Ma, 2011; Maltese & Tai, 2011; Miller & Kimmel, 2012; Nicholls et al., 2010; Riegle-Crumb & King, 2010; Wang, 2013a; You, 2013
Other[a]	8	34.8	Burge, 2013; Crisp et al., 2009; Dynarski et al., 2013; Engberg & Wolniak, 2013; Espinosa, 2011; Gottfried & Williams, 2013; Miller & Kimmel, 2012; Thompson & Bolin, 2011
Grade point average	7	30.4	Ackerman et al., 2013; Engberg & Wolniak, 2013; Espinosa, 2011; Griffith, 2010; Kokkelenberg & Sinha, 2010; Rohr, 2012; Shaw & Barbuti, 2010
SAT or ACT scores	7	30.4	Ackerman et al., 2013; Crisp et al., 2009; Griffith, 2010; Harwell et al., 2012; Kokkelenberg & Sinha, 2010; Nicholls et al., 2010; Rohr, 2012
Student noncognitive factors	7	30.4	Engberg & Wolniak, 2013; Ma, 2011; Nicholls et al., 2010; Riegle-Crumb & King, 2010; Shaw & Barbuti, 2010; Wang, 2013a, 2013b
Parent characteristics	5	21.7	Burge, 2013; Espinosa, 2011; Miller & Kimmel, 2012; Nicholls et al., 2010; You, 2013
School characteristics	3	13.0	Espinosa, 2011; Nicholls et al., 2010; You, 2013
Standardized state test scores	2	8.7	Dynarski et al., 2013; Wang, 2013b
Teacher characteristics	2	8.7	Maltese & Tai, 2011; Miller & Kimmel, 2012
STEM pedagogy	1	4.3	Harwell et al., 2012

STEM is science, technology, engineering, and math.

a. Includes class size, math curriculum, extracurricular STEM club participation, science fair participation, high school class rank, and specific measures of student attitudes toward math and science.

Source: Authors' compilation.

Table A4. Studies by postsecondary STEM outcome

Postsecondary outcome	Number of studies (n = 23)	Percent
Intending to pursue a STEM major	11	47.8
Completing a postsecondary STEM degree	11	47.8
Persisting in a STEM major	7	30.4
Other	4	17.4
Enrolling in a STEM major	4	17.4
Pursuing a STEM career	2	8.7

STEM is science, technology, engineering, and math.

Source: Authors' compilation.

Appendix B. Abstracts of reviewed studies

This appendix includes abstracts by the original author or authors of each study in the literature review.

Ackerman, P. L., Kanfer, R., & Calderwood, C. (2013). High school Advanced Placement and student performance in college: STEM majors, non-STEM majors, and gender differences. *Teachers College Record, 115*(10), 1–43. http://eric.ed.gov/?id=EJ1020012

Author-supplied abstract:

Background/Context: The past few decades have seen an explosive growth in high-school student participation in the Advanced Placement program® (AP), with nearly two million exams completed in 2011. Traditionally, universities have considered AP enrollment as an indicator for predicting academic success during the admission process. However, AP exam performance may be predictive of future academic success; a related factor in gender differences in major selection and success; and instrumental in predicting STEM persistence.

Purpose: This study focused on determining the influence of patterns of AP exam completion and performance on indicators of post-secondary academic achievement. These patterns were examined in the context of gender differences and for the prediction of grades, STEM persistence and graduation rates. Subjects: The sample consisted of 26,693 students who entered the Georgia Institute of Technology (Georgia Tech) as first-year undergraduate students during the period of 1999–2009.

Research Design: Archival admissions records and college transcripts were obtained for entering first-year (non-transfer) students, to examine patterns of AP exams completed and performance on the exams, as they related to indicators of college academic performance, inflow and outflow STEM majors and non-STEM majors, and attrition/time-to-degree criteria. For predicting college performance, patterns of AP exams were examined in isolation, exams grouped by domain, and instances of multiple examinations completed (for example, three or more AP exams in the STEM area). These patterns of AP exams were evaluated for predictive validity in conjunction with traditional predictors of post-secondary performance (for example, high-school GPA and SAT scores). College course enrollment patterns were also examined, in conjunction with AP exam patterns, to determine the associations between AP exam performance and course-taking patterns in post-secondary study.

Data Collection and Analysis: Admissions records were obtained from Georgia Tech, including high-school grade point average information, along with college transcripts, including initial and final major declaration, attrition, and graduation data. Course enrollments were classified by level and by domain. Advanced Placement exam and SAT records were obtained from the College Board, and matched to the Georgia Tech records.

Conclusions/Recommendations: Although student completion of AP exams was positively related to post-secondary grades and graduation rates, this overall pattern masks the relation between AP exam performance and post-secondary success. Students who did not receive credit tended to perform at a level similar to those students who did not complete any AP exams. Increasing numbers of AP-based course credits were associated with higher

GPAs at Georgia Tech for the first year and beyond. Students with greater numbers of AP-based course credits tended to complete fewer lower-level courses and a greater number of higher-level courses. Such students graduated at a substantially higher rate and in fewer semesters of study. Average AP exam score was the single best predictor of academic success after high school GPA (HSGPA). The most important predictors of STEM major persistence were receiving credit for AP Calculus and if the student had successfully completed three or more AP exams in the STEM area. Men had substantially higher rates of these AP exam patterns, compared to women. Given that slightly over half of the AP exams are now completed by high school students prior to their senior year, it is recommended that admissions committees consider use of actual AP exam performance data, in addition to, or instead of AP enrollment data as indicators for predicting post-secondary academic performance.

Burge, S. W. (2013). Cohort changes in the relationship between adolescents' family attitudes, STEM intentions and attainment. *Sociological Perspectives, 56*(1), 49–73.

Author-supplied abstract:

This study examines cohort change in the effect of adolescents' family attitudes—the importance they attach to future marriage and parenthood—on their intentions to major in Science, Technology, Engineering, and Math (STEM) and attainment of STEM bachelor's degrees between the 1970s and 1990s. Using the National Longitudinal Study of the High School Class of 1972 and the National Education Longitudinal Study of 1988, the author investigates whether the gendered relationship between family attitudes and STEM attainment changed during a period characterized by shifting ideas about gender, as well as increasing opportunities for women. In the 1970s, family attitudes negatively affected only women's STEM intentions and attainments. This study presents the novel finding that by the 1990s, both family-oriented young women and men were less likely to intend to major in STEM fields. Still, women who placed high priority on family had lower STEM attainments than similarly family-oriented men in the 1990s, even after controlling for STEM intentions.

Crisp, G., Nora, A., & Taggart, A. (2009). Student characteristics, pre-college, college, and environmental factors as predictors of majoring in and earning a STEM degree: An analysis of students attending a Hispanic serving institution. *American Educational Research Journal, 46*(4), 924–942. http://eric.ed.gov/?id=EJ883302

Author-supplied abstract:

This study examined the demographic, pre-college, environmental, and college factors that impact students' interests in and decisions to earn a science, technology, engineering, or mathematics (STEM) degree among students attending a Hispanic Serving Institution (HSI). Results indicated that Hispanic students were well represented among STEM majors, and students' decisions to declare a STEM major and earn a STEM degree were uniquely influenced by students' gender, ethnicity, SAT math score, and high school percentile. Earning a STEM degree was related to students' first-semester GPA and enrollment in mathematics and science "gatekeeper" courses. Findings indicate that HSIs may be an important point of access for students in STEM fields and may also provide opportunity for more equitable outcomes for Hispanic students.

Dynarski, S., Hyman, J., & Schanzenbach, D. W. (2013). Experimental evidence on the effect of childhood investments on postsecondary attainment and degree completion. *Journal of Policy Analysis & Management, 32*(4), 692–717. http://eric.ed.gov/?id=EJ1027692

Author-supplied abstract:

This paper examines the effect of early childhood investments on college enrollment and degree completion. We used the random assignment in Project STAR (the Tennessee Student/Teacher Achievement Ratio experiment) to estimate the effect of smaller classes in primary school on college entry, college choice, and degree completion. We improve on existing work in this area with unusually detailed data on college enrollment spells and the previously unexplored outcome of college degree completion. We found that assignment to a small class increases students' probability of attending college by 2.7 percentage points, with effects more than twice as large among black students. Among students enrolled in the poorest third of schools, the effect is 7.3 percentage points. Smaller classes increased the likelihood of earning a college degree by 1.6 percentage points and shifted students toward high-earning fields such as STEM (science, technology, engineering, and mathematics), business, and economics. We found that test-score effects at the time of the experiment were an excellent predictor of long-term improvements in postsecondary outcomes.

Engberg, M. E., & Wolniak, G. C. (2013). College student pathways to the STEM disciplines. *Teachers College Record*, *115*(1), 1–27. http://eric.ed.gov/?id=EJ1018167

Author-supplied abstract:

As concerns mount about the shortage of students entering science, technology, engineering, and math (STEM) careers, policy makers throughout the United States are contemplating strategies to maintain and enhance our nation's economic vitality and international competitiveness. Within this policy and program environment, researchers have focused considerable attention on improving STEM education at different stages of the educational pipeline, yet we lack evidence on how resources from one educational setting may influence outcomes in a successive educational setting.

Purpose/Objective/Research Question/Focus: The purpose of the study is to examine individual- and school-level factors that influence students' pathways to the STEM fields during college. Focusing on the importance of high school-to-college linkages, our research questions address the individual and institutional factors that affect students' likelihoods of majoring in a STEM field in college.

Research Design: The study is based on data collected through the Education Longitudinal Study of 2002, a nationally representative survey of high school sophomores who were followed through high school and into college. Students who were enrolled in a four-year institution at the end of 2006 and had declared a major were included in the analytic sample. Analysis: In addition to performing descriptive and factor analyses, we used cross-classified hierarchical general linear modelling to examine students' backgrounds, aptitudes, attitudes, dispositions, and experiences in relation to majoring in a STEM field, as well as institutional factors that constitute students' secondary and postsecondary environments.

Findings/Conclusions: Findings from the study revealed significant effects in relation to race, academic preparation, attitudes and dispositions toward math and science, college choice considerations, and postsecondary experiences. Although no institutional effects were uncovered at the high school level, both postsecondary sector and selectivity significantly influenced propensities toward majoring in a STEM discipline. The study concludes with several policy recommendations related to K–16 collaborations, dual-enrollment programs, and developmental considerations for teachers and counselors working with high school students.

Espinosa, L. L. (2011). Pipelines and pathways: Women of color in undergraduate STEM majors and the college experiences that contribute to persistence. *Harvard Educational Review, 81*(2), 209–241. http://eric.ed.gov/?id=EJ931611

Author-supplied abstract:

Supporting undergraduate achievement in science, technology, engineering, and mathematics (STEM) disciplines is paramount to ensuring our nation's continued scientific and technological advancement. In this quantitative study, Lorelle Espinosa examines the effect of precollege characteristics, college experiences, and institutional setting on the persistence of undergraduate women of color in STEM majors and also investigates how this pathway might differ for women of color in comparison to their White peers. She utilized hierarchical generalized linear modeling (HGLM) to examine the experiences of 1,250 women of color and 891 White women attending 135 institutions nationwide. Results revealed the paramount role of women's college experiences. Women of color who persisted in STEM frequently engaged with peers to discuss course content, joined STEM-related student organizations, participated in undergraduate research programs, had altruistic ambitions, attended private colleges, and attended institutions with a robust community of STEM students. Negative predictors of persistence include attending a highly selective institution.

Gottfried, M. A., & Williams, D. (2013). STEM club participation and STEM schooling outcomes. *Education Policy Analysis Archives*, *21*(79), 1–23. http://eric.ed.gov/?id=EJ1018827

Author-supplied abstract:

To develop a more robust understanding of the relationship between non-formal, school based STEM activities and students' success and persistence in STEM fields, this study evaluates how math club participation influences math GPA and how science club participation influences science GPA. Additionally, this study evaluates how math or science club participation associates with the probability of selecting a STEM major in college. Utilizing data from the National Longitudinal Study of Adolescent Health (Add Health) to examine these relationships, the results suggest that there is a STEM achievement gap in the success and persistence of students who do and do not participate in STEM-related extracurricular clubs. While, for the most part, the results were not differentiated by gender or race/ethnicity per se, they were in fact distinguishable by poverty status and the interaction between race and poverty status.

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review, 29*(6), 911–922. http://eric.ed.gov/?id=EJ905602

Author-supplied abstract:

During college, many students switch from their planned major to another, particularly so when that planned major was in a Science, Technology, Engineering, or Mathematics (STEM) field. A worrying statistic shows that persistence in one of these majors is much lower for women and minorities, suggesting that this may be a leaky joint in the STEM pipeline for these two groups of students. This paper uses restricted-use data from the National Longitudinal Survey of Freshmen (NLSF) and the National Education Longitudinal Study of 1988 (NELS:88) to examine which factors contribute to persistence of all students in STEM field majors, and in particular the persistence of women and minorities. Although descriptive statistics show that a smaller percentage of women and minorities persist in a STEM field major as compared to male and non-minority students, regression analysis shows that differences in preparation and the educational experiences of these students explain much of the differences in persistence rates. Students at selective institutions with a large graduate to undergraduate student ratio and that devote a significant amount of spending to research have lower rates of persistence in STEM fields. A higher percentage of female and minority STEM field graduate students positively impacts on the persistence of female and minority students. However, there is little evidence that having a larger percentage of STEM field faculty members that are female increases the likelihood of persistence for women in STEM majors. These results suggest that the sorting of women and minorities into different types of undergraduate programs, as well as differences in their backgrounds, have a significant impact on persistence rates.

Harwell, M. R., Medhanie, A., Post, T. R., Norman, K., & Dupuis, D. N. (2012). Preparation of students completing a Core-Plus or commercially developed high school mathematics curriculum for intense college mathematics coursework. *Journal of Experimental Education, 80*(1), 96–112. http://eric.ed.gov/?id=EJ949929

Author-supplied abstract:

The purpose of this study was to examine the college mathematics achievement and course-taking of students at a large public research university who completed a commercially developed or standards-based (Core-Plus) high school mathematics curriculum, and who subsequently completed at least 2 college mathematics courses of difficulty level at or beyond precalculus mathematics. Mathematics course-taking and achievement data across 8 college semesters were analyzed for a sample of 1,588 students. Findings indicated that students (including science, technology, engineering, and mathematics majors) were equally prepared for intense college mathematics coursework regardless of which high school mathematics curriculum they completed. These findings inform high school mathematics curriculum adoption decisions for college-bound students, and college policies and practices for advising students enrolling in mathematics courses.

Ing, M., & Nylund-Gibson, K. (2013). Linking early science and mathematics attitudes to long-term science, technology, engineering, and mathematics career attainment: Latent class analysis with proximal and distal outcomes. *Educational Research and Evaluation, 19*(6), 510–524.

Author-supplied abstract:

There is a need to identify students' early attitudes toward mathematics and science to better support their long-term persistence in science, technology, engineering, and mathematics (STEM) careers. Seventh graders from a nationally representative sample (N = 2,861) were classified based on their responses to questions about their attitudes toward mathematics and science using latent class analysis. Four distinct groups of students that differed in terms of their attitudes were identified. There were relationships between attitudinal group membership, demographic characteristics, mathematics and science achievement, and STEM career attainment. Females and underrepresented minorities were more likely to be in the positive attitude group. However, despite these early positive attitudes, females and underrepresented minorities were less likely to be employed in a STEM career some 20 years later. Information about student interests organized in this manner can be used to better target specific interventions to support and encourage persistence in STEM careers.

Kokkelenberg, E. C., & Sinha, E. (2010). Who succeeds in STEM studies? An analysis of Binghamton University undergraduate students. *Economics of Education Review, 29*(6), 935–946. http://eric.ed.gov/?id=EJ905609

Author-supplied abstract:

Using student level data, the characteristics of STEM and non-STEM students are examined for attributes associated with academic success. We use fixed effects models to analyze the variables' role in attaining graduation and college GPA and find preparation and ability, as evidenced by Advanced Placement course work, mathematical ability, gender, ethnicity, high school GPA and college experience are all statistically significant indicators of success. These attributes may confer a comparative advantage to STEM students. The engineers have statistically significant differing response elasticities than the non-engineers, and show evidence of persistence that may arise from learning-by-doing. A successful engineering STEM major at Binghamton has good mathematics preparation, and disproportionately is of Asian ethnicity. Women are few in numbers as engineers. Other STEM fields see less emphasis on mathematics preparation, but more emphasis on the presence of AP course work. Women have the same presence in these other STEM fields as in the whole university.

Ma, Y. (2011). Gender differences in the paths leading to a STEM baccalaureate [My pathway]. *Social Science Quarterly, 92*(5), 1169–1190.

Author-supplied abstract:

Many have wondered why U.S. women continue to shun certain STEM fields, including science, technology, engineering, and mathematics. This study investigates this question and examines the pathways that women and men follow in attaining their STEM bachelor's degrees.

Methods: Using NELS 88–00 and the postsecondary transcript data, the descriptive analysis examines gender differences in the three stages of the STEM pipeline: expected college major, first major, and bachelor degree major. The multivariate analysis examines the outcomes of STEM degree attainment, the subfields attainment and the pathways in a series of logical steps.

Results: Drawing from the pipeline model and its associated cumulative disadvantage theory, and the alternative framework of revolving door theory, analyses from this study indicate that men are more likely than women to follow the complete persistence pathway to attain STEM degrees, but women are as persistent as men once they expect a major in STEM as high school seniors. High school achievement, attitudes, and course taking are related to the subfields attainment, as well as the pathways of the STEM degree attainment.

Conclusions: Taken together, the results are more aligned with revolving door theory and support the contextual variability in the salience of gender to understand gender differences in attaining STEM fields.

Maltese, A. V., & Tai, R. H. (2011). Pipeline persistence: Examining the association of educational experiences with earned degrees in STEM among U.S. students. *Science Education*, *95*(5), 877–907. http://eric.ed.gov/?id=EJ936523

Author-supplied abstract:

As the global economic crisis continues, sustaining the United States' position as a leader in research and development is a top concern of policy makers. Looking to increase the number of students pursuing degrees in STEM (science, technology, engineering, and mathematics), calls for improved mathematics and science education abound. We completed a two-part analysis to assess the school-based factors related to students choosing to complete a major in STEM. The results indicate that the majority of students who concentrate in STEM make that choice during high school, and that choice is related to a growing interest in mathematics and science rather than enrollment or achievement. These results indicate that the current policy focus on advanced-level course taking and achievement as measures to increase the flow of students into STEM may be misguided.

Miller, J. D., & Kimmel, L. G. (2012). Pathways to a STEMM profession. *Peabody Journal of Education*, *87*(1), 26–45. http://eric.ed.gov/?id=EJ971399

Author-supplied abstract:

The inadequate number of American young adults selecting a scientific or engineering profession continues to be a major national concern. Using data from the 23-year record of the Longitudinal Study of American Youth (LSAY) and working within the social learning paradigm, this analysis uses a set of 21 variables to predict young people's employment in science, technology, engineering, mathematics, or medicine (STEMM) at ages 36 to 39. The LSAY is one of the longest and most intensive longitudinal studies of the impact of secondary education and postsecondary education conducted in the United States. Using a structural equation model, the study found that mathematics continues to be a primary gateway for STEMM professions, beginning with algebra track placement in grade eight and continuing through high school and college calculus courses. Home and family factors such as parent education and parent encouragement of science and mathematics during secondary school also enhanced the likelihood of entering a STEMM profession.

Nicholls, G. M., Wolfe, H., Besterfield-Sacre, M., & Shuman, L. J. (2010). Predicting STEM degree outcomes based on eighth grade data and standard test scores. *Journal of Engineering Education, 99*(3), 209–223.

Author-supplied abstract:

A study examined application of a model to predict science, technology, engineering, and mathematics (STEM) degree outcomes on the basis of eighth-grade data and high school standardized test scores. Results indicated that the modeling process was able to identify STEM students and other degree students potentially capable of studying for a STEM degree.

Riegle-Crumb, C., & King, B. (2010). Questioning a White male advantage in STEM: Examining disparities in college major by gender and race/ethnicity. *Educational Researcher, 39*(9), 656–664. http://eric.ed.gov/?id=EJ912229

Author-supplied abstract:

The authors analyze national data on recent college entrants to investigate gender and racial/ethnic disparities in STEM fields, with an eye toward the role of academic preparation and attitudes in shaping such disparities. Results indicate that physical science/engineering (PS/E) majors are dominated by men, but not, however, disproportionately by White men. After accounting for high school preparation, the odds of declaring a PS/E major are two times greater for Black males than for White males, and Black females are closer than White females to closing the gap with White males. The authors find virtually no evidence that math attitudes contribute to disparities in choice of a PS/E major. Finally, in contrast to PS/E fields, biological sciences draw relatively equitably from all groups.

Rohr, S. L. (2012). How well does the SAT and GPA predict the retention of science, technology, engineering, mathematics, and business students. *Journal of College Student Retention: Research, Theory and Practice, 14*(2), 195–208. http://eric.ed.gov/?id=EJ979197

Author-supplied abstract:

This study examined the relationship between various admissions selection criteria utilized by a small, Liberal Arts College in Indiana. More specifically, the study examined if a higher college preparatory GPA and a higher aggregate score on the SAT helped predict the retention of science, technology, engineering, mathematics, and business students. Data was gathered using historical enrollment data of 803 students. A logistic regression analysis was utilized to examine the impact of the two variables on retention of science, technology, engineering, mathematics, and business students. College preparatory GPA and the aggregate SAT score were predictors of retention of science, technology, engineering, mathematics, and business students. For every point increase in GPA, the odds were more than twice as much that the student would be retained. For every point increase in SAT, there was 0.3 percent increase in retention.

Shaw, E. J., & Barbuti, S. (2010). Patterns of persistence in intended college major with a focus on STEM majors. *NACADA Journal, 30*(2), 19–34. http://eric.ed.gov/?id=EJ906475

Author-supplied abstract:

In this study, we examined patterns of persisting in and switching from an intended college major (chosen in high school) in the third year of college. We focused on science, technology, engineering, and math (STEM) major persistence because of the national effort to increase those entering STEM careers. Results showed differences in persistence by academic field as well as by gender, parental income, and first-generation college student status with the largest variation by ethnicity. Further examination of STEM major persistence showed that high school performance in math and science, taking advanced placement exams in STEM, articulating positive science self-efficacy beliefs, and professing a goal of obtaining a doctorate were also related to persistence in varied ways across STEM majors.

Thompson, R., & Bolin, G. (2011). Indicators of success in STEM majors: A cohort study. *Journal of College Admission 212*(1), 18–24. http://eric.ed.gov/?id=EJ939062

Author-supplied abstract:

It has become universally known that Americans as a nation have fallen behind other nations in the areas of science, technology, engineering, and mathematics (STEM). According to the National Science and Engineering Indicators, produced by the National Science Foundation in 2006, the United States has one of the lowest STEM to non-STEM degree rates in the world. Efforts to combat the well-documented problem have recently taken on a new momentum. In this study, the authors seek to determine what factors, if any, might serve as indicators of successful matriculation of first-time freshmen students enrolled in STEM majors in a large emerging public institution in Texas. They also seek to disaggregate the data based on gender, ethnicity, county of origin, and high school ranking, as well as track a cohort of students through a seven-year continuum to determine if the students drop out of the university completely, switch from one major to another and/or graduate. Furthermore, the analysis is conducted for the three largest majors (based on enrollment) at this university, STEM, Business and Education, to determine if the factors are contingent upon the selected major. While the findings of this study demonstrate statistical significance, more research should be conducted, specifically addressing the needs of STEM students in years four and five of their program.

Tyson, W., Lee, R., Borman, K. M., & Hanson, M. A. (2007). Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk, 12*(3), 243–270. http://eric.ed.gov/?id=EJ780680

Author-supplied abstract:

This article examines how high school science and mathematics course-taking creates pathways toward future baccalaureate degree attainment in science, technology, engineering, and mathematics (STEM) majors in Florida 4-year universities using Burkam and Lee's (2003) course-taking categories developed using national student datasets. This study finds that even though women, overall, complete high-level courses, they do not complete the highest level science and mathematics courses. Even women who did complete high-level science and mathematics are less likely than men to obtain STEM degrees. Black and Hispanic students complete lower level high school courses, but Black and Hispanic students who did take high-level courses are as likely as White students to pursue STEM degrees. Findings suggest that gender disparities in STEM occur because women are less likely to pursue STEM, but racial disparities occur because fewer Black and Hispanic students are prepared for STEM in high school.

Wang, X. (2013a). Modeling entrance into STEM fields of study among students beginning at community colleges and four-year institutions. *Research in Higher Education, 54*(6), 664–692. http://eric.ed.gov/?id=EJ1039145

Author-supplied abstract:

In this study, a theoretical model is tested to examine factors shaping the decision to pursue STEM fields of study among students entering community colleges and four-year institutions, based on a nationally representative sample of high school graduates from 2004. Applying the social cognitive career theory and multi-group structural equation modeling analysis, this research highlights a number of findings that may point to specific points of intervention along students' educational pathway into STEM. This study also reveals important heterogeneity in the effects of high school and postsecondary variables based on where students start their postsecondary education: community colleges or four-year institutions. For example, while high school exposure to math and science courses appears to be a strong influence on four-year beginners' STEM interest, its impact on community college beginners' STEM interest, albeit being positive, is much smaller. In addition, college academic integration and financial aid receipt exhibit differential effects on STEM entrance, accruing more to four-year college students and less to those starting at community colleges.

Wang, X. (2013b). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. *American Educational Research Journal, 50*(5), 1081–1121. http://eric.ed.gov/?id=EJ1018916

Author-supplied abstract:

This study draws upon social cognitive career theory and higher education literature to test a conceptual framework for understanding the entrance into science, technology, engineering, and mathematics (STEM) majors by recent high school graduates attending 4-year institutions. Results suggest that choosing a STEM major is directly influenced by intent to major in STEM, high school math achievement, and initial postsecondary experiences, such as academic interaction and financial aid receipt. Exerting the largest impact on STEM entrance, intent to major in STEM is directly affected by 12th-grade math achievement, exposure to math and science courses, and math self-efficacy beliefs—all three subject to the influence of early achievement in and attitudes toward math. Multiple-group structural equation modeling analyses indicated heterogeneous effects of math achievement and exposure to math and science across racial groups, with their positive impact on STEM intent accruing most to White students and least to underrepresented minority students.

You, S. (2013). Gender and ethnic differences in precollege mathematics coursework related to science, technology, engineering, and mathematics (STEM) pathways. *School Effectiveness and School Improvement, 24*(1), 64–86. http://eric.ed.gov/?id=EJ995084

Author-supplied abstract:

In 2004, the pattern in academic pathways for high school students in the USA showed that students were completing more demanding mathematics courses. Despite the upward pattern in advanced-level mathematics course-taking, disparities among racial/ethnic groups persisted between 1982 and 2004. Using data from the Education Longitudinal Study of 2002 (ELS: 2002; Ingels et al., 2007), the current study sought to advance understanding of gender and ethnic differences in advanced mathematics course-taking. Furthermore, this study examined how the differences are related to science, technology, engineering, and mathematics (STEM) pathways in college. Results showed that the relationships between exploratory factors (both individual- and school-level factors) and advanced mathematics course-taking and STEM choices differed across ethnicity and gender. This highlights the need for further research that disaggregates data by both ethnicity and gender.

Appendix C. Detailed findings by study

Table C1 summarizes various aspects of each study in the literature review, including details about the sample examined, the outcomes of interest, the K–12 indicators tested, sample size, the years covered, the design, the most relevant findings, the limitations, and the extent to which results were examined separately for Hispanic or racial/ethnic minority students.

Table C1. Detailed findings by study

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Ackerman et al. (2013)	2,693 first-year undergraduates at Georgia Institute of Technology	Postsecondary (data included from high school)	• Declaring a STEM major. • Persisting in a STEM major. • STEM major grades. • Completing a postsecondary STEM degree (and semesters to completion).	• Total number of Advanced Placement courses taken. • Advanced Placement exam scores. • SAT math and verbal scores. • High school grade point average.	1999–2009	Correlational (independent variables added to model simultaneously but no background controls)	Successfully completing Advanced Placement exams in general—and depending on the student's major, specific Advanced Placement exams in particular—is associated with higher rates of persisting in a STEM major, higher graduation rates, and fewer semesters to graduation.	• Demographic background unknown and unaccounted for. • Sample limited to undergraduate students at a single institution. • Does not account for school differences in Advanced Placement course availability.	• No Hispanic focus. • No subgroup analyses or demographic data included.
Burge (2013)	4,450 students from the National Longitudinal Study of 1972 and 3,772 students from the National Education Longitudinal Study of 1988	Grade 12–postsecondary	• Completing a postsecondary STEM degree.	• Attitudes about marriage and parenthood.	1972–74 and 1992–94	Correlational with control variables	The importance placed on parenthood was negatively related to women's (but not men's) likelihood of graduating with a bachelor's degree in a STEM major for both the 1970s and 1990s cohorts. Among adolescents who put a low priority on parenthood, there was no gender difference in the rate of completing a STEM degree (controlling for academics and background factors), but among adolescents who put a high priority on parenthood, men were three times as likely as women to complete a STEM degree.	• No Hispanic subgroup analyses (small proportion of sample).	• Hispanic race/ethnicity used as demographic control variable only. • No subgroup analyses.
Crisp et al. (2009)	1,925 students who received an undergraduate degree between 2006 and 2008 from one large doctoral-granting Hispanic-serving institution in the southwestern United States	Postsecondary (data included from high school)	• Declaring a STEM major. • Completing a postsecondary STEM degree.	• SAT math scores. • High school percentile ranking.	2006 –08	Correlational with control variables	SAT math scores and high school percentile ranking were both predictive of declaring a STEM major and graduating with a STEM degree. Hispanic students were more likely than White students to declare a STEM major (but not significantly more likely to graduate with a STEM degree).	• Sample limited to undergraduate students at a single institution. • Predictors limited to available institutional data.	• 48 percent of sample Hispanic. • Subgroup analyses conducted for Hispanic students comparing predictors for Hispanic versus White students.

(continued)

Table C1. Detailed findings by study *(continued)*

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Dynarski et al. (2013)	11,269 students randomly assigned to small or regular-sized K–3 classrooms in Tennessee Student/Teacher Achievement Ratio Project	K–postsecondary	• Completing a postsecondary STEM degree.	• K–3 class size.	1985–86, outcome measured 2006 and 2010	Randomized controlled trial	Being assigned to a small class increased the rate of postsecondary attendance, and the effects were considerably higher among populations with traditionally low rates of postsecondary attainment (Black students and students receiving free or reduced-price lunch). Effects were largest for children in schools with a high percentage of poverty. Smaller classes shifted students toward earning degrees in STEM, business, and economics and toward graduating with a STEM, business, or economics degree among the less-poor schools	• Hispanic race/ethnicity not included. • Missing postsecondary data for approximately 20 percent of the sample.	• Hispanic race/ethnicity not included in analyses.
Engberg & Wolniak (2013)	Subset of Education Longitudinal Study of 2002: 4,180 high school graduates in 2004 who enrolled in postsecondary education and declared a major in 2006	Grade 10–postsecondary	• Declaring a STEM major.	*Individual level* • Grade point average. • Highest level math or science course taken. • Student interest in math. • Self-efficacy in math. • Math engagement. *School level* • High school sector. • Region. • College guidance program. • College preparatory program. • Overall learning environment.	2002–06	Correlational with control variables; cross-classified hierarchical linear modeling	All high school preparatory (highest level math or science course taken, grade point average) and dispositional variables (interest in math, self-efficacy in math, math engagement) were highly significant. The strongest was highest level math or science course taken. High school characteristics and environment variables were not associated with declaring a STEM major.	• No Hispanic subgroup analyses (small proportion of sample).	• Hispanic used as demographic control variable only. • No subgroup analyses.

(continued)

Table C1. Detailed findings by study *(continued)*

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Espinosa (2011)	1,250 racial/ethnic minority women (37 percent Hispanic) at 96 institutions and 891 White women at 123 institutions with intent to pursue a STEM major.	Postsecondary (report retrospectively on grades 9–12)	• Persisting in a STEM major.	• Years of math and biological and physical sciences courses. • High school grade point average.	2004–08	Correlational with control variables	High school grade point average was significantly related to persisting in a STEM major in both samples. It was the only K–12 predictor that was significant for both racial/ethnic minority women and White women once all measures were included in the model. Both maternal education and parent concern about college affordability were predictive for White women but not for racial/ethnic minority women.	• Survey nonresponse bias. • Does not look at Hispanic people separately—racial/ethnic minority women are looked at as a group. • Sample is exclusively full-time, four-year college students with intent to pursue a STEM major at the beginning of freshman year.	• Compares racial/ethnic minority women to White women. • Does not break out racial/ethnic minority women by race/ethnicity.
Gottfried & Williams (2013)	3,220 students from the Longitudinal Study of Adolescent Health	Grade 7–postsecondary	• Declaring a STEM major.	• Participation in math or science extracurricular club. • Highest level math or science course completed. • Percentage of math or science semesters failed. • Interest in attending college. • Peabody Vocabulary Test score. • Parent interest in child's grades.	1994–2002	Correlational with control variables, propensity score analysis	Students who participated in math or science clubs were three times as likely to pursue a STEM major in college. After employing propensity score matching, the odds were tempered. Statistically significant relationships between math club participation (but not science club) and pursuing a STEM major were still found. Results were similar regardless of race/ethnicity, though results were not significant for poor students.	• Does not take into account differences in clubs. • Although propensity score analysis may reduce selection bias, it does not eliminate it; therefore results cannot be interpreted as causal.	• Race/ethnicity interacted with predictors.

(continued)

Table C1. Detailed findings by study *(continued)*

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Griffith (2010)	5,500 students from the National Education Longitudinal Study of 1988 and 8,015 incoming freshmen at 28 selective colleges and universities in fall 1999 from the National Longitudinal Study of 1972	Grade 8–postsecondary	• Intent to pursue a STEM major. • Persisting in STEM major.	• Grade point average. • Advanced Placement courses. • SAT scores.	1988–2008	Correlational with control variables	Grade point average and percentage of Advanced Placement STEM courses are positively associated with intent to pursue a STEM major and persisting in a STEM major. SAT score is positively related to intent to pursue a STEM major for the National Education Longitudinal Study sample but not the National Longitudinal Study freshmen sample. SAT scores are positively related to persisting in a STEM major for both samples. Although female and racial/ethnic minority students have lower average persistence rates in STEM majors, the difference disappears or is reversed once background and institutional characteristics are controlled for. Taking more Advanced Placement STEM courses and holding total number of Advanced Placement courses taken constant has a positive impact on persistence rates for female and racial/ethnic minority students.	• National Longitudinal Study of freshman data are specific to students at selective four-year colleges and universities. • Data are outdated.	• Subgroup analyses grouping racial/ethnic minority students.
Harwell et al. (2012)	1,588 students at a large public research university who completed at least two college math courses of difficulty at or beyond precalculus math	Postsecondary (data included from high school)	• Grades in advanced math courses.	• Commercially developed versus the National Science Foundation–funded Core-Plus high school math curriculum. • High school math grade point average. • ACT math score. • Number of years of high school math.	2002–03	Correlational with minimal controls (gender and race/ethnicity)	High school math grade point average and ACT math score were predictive of students' first college math course grade. Students who attended high schools using the Core-Plus curriculum scored just as well in their math courses as students in schools using commercially developed curriculum.	• No Hispanic subgroup analyses. • Sample limited to undergraduates at a single institution.	• Hispanic race/ethnicity used as demographic control variable only. • No subgroup analyses.

(continued)

Table C1. Detailed findings by study *(continued)*

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Ing & Nylund-Gibson (2013)	2,861 students from the 1987 Longitudinal Study of American Youth (who completed the 2007 survey)	Grade 7–postsecondary	• STEM career.	• Attitudes about math and science (latent class analysis used to categorize into four groups).	1987–2007	Correlational, no controls	Students who fell into the "positive" class had the most positive attitudes toward math and science in grade 7. These students were most likely to be in STEM occupations 20 years later. Underrepresented racial/ethnic minority (non-Asian and non-White) and female students were more likely to be in the "positive" group but less likely to be in STEM careers 20 years later despite these early positive attitudes.	• Information on STEM careers but no information on STEM postsecondary degrees. • Data are outdated.	• Looks at whether racial/ethnic minority status is correlated with math and science attitudes and whether these attitudes are correlated with later outcomes but does not compare the correlation between class and outcomes for different subgroups.
Kokkelenberg & Sinha (2010)	44,324 State University of New York at Binghamton students from fall 1997 through spring 2007 (926,759 observations)	Postsecondary (data included from high school)	• Undergraduate grade point average. • Completing a postsecondary STEM degree.	• SAT math and verbal scores. • Number of Advanced Placement courses taken (STEM and non-STEM).	1997–2007	Correlational with control variables and school-level fixed effects	For engineers high school math preparation is predictive of STEM success (grade point average and graduating with a STEM degree). For other STEM majors Advanced Placement courses taken and SAT math scores are predictive of STEM success. The number of Advanced Placement non-STEM courses and SAT verbal scores are negatively correlated with graduating with a STEM major. Hispanic students have lower STEM success than White students.	• Small number of Hispanic students, no subgroup analyses. • Sample limited to undergraduate students at a single institution. • Predictors limited to available institutional data.	• Hispanic race/ethnicity used as demographic control variable only. • No subgroup analyses.

(continued)

Table C1. Detailed findings by study *(continued)*

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Ma (2011)	4,036 students from the National Education Longitudinal Study of 1988 (nationally representative)	Grade 8–postsecondary	• Declaring a STEM major. • Completing a postsecondary STEM degree.	• Math and science courses taken. • National Education Longitudinal Study of 1988–administered standardized tests (math, science, and reading). • Self-assessment of ability. • Scores on scales of importance of money and importance of helping others.	1988 followed through 2001	Correlational with control variables	Science achievement test scores were significantly related to completing a postsecondary STEM degree. Math achievement test scores were not significantly related to completing a postsecondary STEM degree after high school courses taken were taken into account. Positive self-assessment in math was associated with completing a postsecondary STEM degree. Math and science courses taken were positively related to completing a postsecondary STEM degree. Women were underrepresented among STEM majors across all races/ethnicities.	• No Hispanic subgroup analyses (small proportion of sample). • Data are outdated.	• Hispanic race/ethnicity used as demographic control variable only. • No subgroup analyses.
Maltese & Tai (2011)	4,700 students from the National Education Longitudinal Study of 1988 (nationally representative)	Grade 8–postsecondary	• Completing a postsecondary STEM degree.	• Grade 8: attitudes toward math, science, and reading. • Science achievement. • Career goals. • High school math and science courses taken (number of and level) and achievement. • Experiences with and attitudes toward math and science as measured for grades 9–10 and again for grades 11–12.	1988 followed through 2001	Correlational with control variables	The number of science courses completed in high school was positively associated with completing a postsecondary STEM degree. Student interest and ratings of their abilities in math and science, measured in different forms, played a significant and positive role in each model evaluated. Students who in grade 8 indicated that they were interested in a science career and those who believed science would be useful in their future were more likely to complete a STEM degree. When asked in grade 12 about their plans for a college major, students who indicated a STEM major were more than three times as likely to complete a STEM degree.	• No Hispanic subgroup analyses (small proportion of sample). • Data are outdated.	• Hispanic race/ethnicity used as demographic control variable only. • No subgroup analyses.

(continued)

Table C1. Detailed findings by study *(continued)*

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Miller & Kimmel (2012)	3,945 students from the 1987 Longitudinal Study of American Youth (who completed the 2007 survey)	Grade 7–postsecondary	• STEM career.	• Math courses taken (early enrollment in algebra, calculus in high school). • High school attitudes toward and interest in math. • Parent focus on college and STEM. • Teacher encouragement. • Math and science achievement.	1987, followed up in 2007	Correlational with control variables	Advanced math courses taken are a primary gateway for STEM professions, beginning with algebra track placement in grade 8 and continuing through high school and college calculus courses. Parent encouragement of science and math during secondary school also increased the likelihood of entering a STEM profession.	• No Hispanic subgroup analyses (small proportion of sample). • Data are outdated.	• Hispanic race/ ethnicity used as demographic control variable only • No subgroup analyses.
Nicholls et al. (2010)	11,320 students from the National Education Longitudinal Study of 1988 (nationally representative)	Grade 8–postsecondary	• Completing a postsecondary STEM degree.	• Parent attitudes about child's schooling. • Math and science grades. • Grade 8 math, science, and reading ability. • SAT or ACT scores.	1988 followed through 2001	Correlational with control variables	Significant predictors of completing a postsecondary STEM degree included overall math proficiency (+), science ability quartile (+), how often parent talked to child about post-high school plans (–), how far in school the parent expected child to go (+), how far in school student thought he or she would go (+), number of hours students worked for pay per week (–), student's math ability (+), math grades in grades 6–8 (+), science grades in grades 6–8 (+), ACT English score (–), ACT math score (+), SAT verbal score (–), and SAT math score (+)	• No Hispanic subgroup analyses (small proportion of sample). • Data are outdated.	• Hispanic race/ ethnicity used as demographic control variable only. • No subgroup analyses.

(continued)

Table C1. Detailed findings by study *(continued)*

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Riegle-Crumb & King (2010)	3,946 students from the Education Longitudinal Study of 2002 (nationally representative); subsample enrolled in a four-year college and declared major in 2006	Grade 10–postsecondary	• Declaring a STEM major.	• Highest level math course taken. • High school math grade point average. • Affection toward math. • Confidence in math. • Education Longitudinal Study of 2002 –administered standardized math test score.	2002–06	Correlational with control variables; propensity score analysis	Accounting for differences in preparation and attitudes toward math does not substantially close the gender gap in declaring a STEM major between Hispanic and White students. After differences in high school academic background are held constant, Black female students come closer to closing the gap with White male students and are more likely to declare a STEM major than White female students. Black and Hispanic male college students are as likely as White male college students to declare a STEM major, despite substantially lower levels of academic preparation. Once these differences are accounted for, Black male students are substantially more likely than White male students to declare a physical science or engineering major.	• Generalizability limited to students enrolled in four-year college.	• Subgroup analyses.
Rohr (2012)	803 first-time undergraduate students at a small liberal arts college in Indiana	Postsecondary (data included from high school)	• Completing a postsecondary STEM degree.	• High school grade point average. • SAT scores.	1992–98	Correlational (independent variables added to model simultaneously but no background controls)	High school grade point average and SAT scores were both predictive of completing a postsecondary STEM degree.	• Demographic background unknown and unaccounted for. • Sample limited to undergraduate students at a single institution.	• No Hispanic focus. • No subgroup analyses or demographic data included.
Shaw & Barbuti (2010)	54,336 students from the SAT Validity Study subsample (2006 cohort in one of 39 universities that submitted declared majors by students' third year)	Postsecondary (data included from high school)	• Declaring a STEM major.	• High school grade point average (overall, math, and science). • Intended major. • Highest degree goal. • Number of Advanced Placement exams taken. • Self-estimate of science ability.	2006–10	Correlational, no controls	High school performance in math and science, taking Advanced Placement STEM exams, articulating positive science self-efficacy beliefs, and professing a goal of obtaining a doctorate were related to declaring a STEM major.	• Completely correlational; no controls attempted and no causality can be interpreted.	• No Hispanic focus. • No subgroup analyses or demographic data included.

(continued)

Table C1. Detailed findings by study *(continued)*

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Thompson & Bolin (2011)	3,531 members of the 2003 cohort of first time to college freshmen at a large research university in Texas	Postsecondary (data included from high school)	• Persisting in a STEM major. • Completing postsecondary STEM degree.	• High school ranking.	2003–10	Correlational, no controls	Higher school ranking was associated with lower rates of switching out of a STEM major, lower rates of dropping out of school entirely, and higher rates of graduating as a STEM major.	• Sample limited to one cohort of undergraduates at a single institution. • Completely correlational; no controls attempted and no causality can be interpreted.	• No Hispanic focus. • No subgroup analyses or demographic data included.
Tyson et al. (2007)	94,078 students who attended one of 350 Florida high schools and any four-year university in Florida	Postsecondary (data included from high school)	• Completing a postsecondary STEM degree.	• Number of math or science courses taken. • Level of math or science courses taken.	1996–97	Correlational with control variables	Black and Hispanic students completed lower high school courses, but Black and Hispanic students who took high-level courses were as likely as White students to complete a STEM degree. Even women who completed high-level science and math were less likely than men to complete a STEM degree.	• Examines the extent to which differences in courses taken explains racial/ ethnic disparities in completing a STEM degree but does not conduct subgroup analyses	• Hispanic race/ ethnicity used as independent variable in predicting high school courses taken and STEM outcomes.
Wang (2013a)	9,770 students from the Education Longitudinal Study of 2002 (nationally representative); subsample who enrolled in postsecondary by 2006	Grade 10–postsecondary	• Declaring a STEM major.	• Perceived adequacy of student's high school math and science coursework for college math and science. • Interest in STEM major (measured in grade 12). • Math self-efficacy. • Number of high school math and science courses taken. • Math standardized score.	2002–06	Correlational with control variables	Math self-efficacy beliefs, exposure to math and science courses, and high school math achievement all showed statistically significant effects on four-year beginners' interest in declaring a STEM major. Exposure to math and science seemed to have the most substantial effect, followed by math self-efficacy beliefs and math achievement. Impact on two-year beginners' interest in STEM was not as substantial. For students entering community college, math self-efficacy beliefs had the strongest influence on interest in STEM, followed by exposure to math and science and math achievement.	• No Hispanic subgroup analyses (small proportion of sample).	• Hispanic race/ ethnicity used as demographic control variable only. • No subgroup analyses.

(continued)

Table C1. Detailed findings by study *(continued)*

Citation	Study sample and size	Grade level	Outcomes of interest	Key K–12 indicators	Years studied	Study design	Relevant findings	Study limitations	Hispanic focus
Wang (2013b)	5,650 students from the subset of Education Longitudinal Study of 2002 (nationally representative) who were high school graduates in 2004 and enrolled in postsecondary education by 2006	Grade 10–postsecondary	• Declaring a STEM major.	• Grade 10 attitudes toward math. • Grade 10 math achievement. • Grade 12 math self-efficacy. • High school exposure to math and science. • Grade 12 math achievement.	2002–06	Correlational with control variables; structural equations modeling	Grade 12 math achievement, math self-efficacy, and math achievement predicted declaring a STEM major, but the effect varied by race/ethnicity. The effect size of grade 12 math achievement and high school math exposure was larger for White students than for underrepresented racial/ethnic minority students. The effect of grade 10 math achievement on grade 12 was largest for underrepresented racial/ethnic minority students.	• Underrepresented racial/ethnic minorities are grouped together and therefore differences among racial/ethnic minorities are not discernible.	• Subgroup analyses conducted comparing predictors for under-represented racial/ethnic minorities (including Black and Hispanic students), and Asian and White students
You (2013)	10,599 students from the Education Longitudinal Study of 2002 (nationally representative)	Grade 10–postsecondary	• STEM courses taken. • Declaring a STEM major	• High school courses taken. • Attitudes and behaviors toward math. • Parent academic expectations. • School climate.	2002–06	Correlational with control variables	Taking calculus in high school was predictive of declaring a STEM major in college across race/ethnicity and gender. Hispanic and Black students took lower math courses in high school, but those who took higher courses were just as likely to pursue a STEM major. Among school climate and process variables examined, average rate of college preparatory program enrollment, perceived high academic climate, degree to which students were satisfied with teachers, and mean level of parents' school participation were all significant predictors.	• No measurement of differences in course offered in schools students attended.	• Subgroup analyses.

Source: Authors' compilation.

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