Stated Briefly

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

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Regional Educational Laboratory Southwest conducted this literature review to identify malleable factors that can be measured in K–12 settings and that predict students' postsecondary science, technology, engineering, and math (STEM) success (defined as enrolling in, persisting in, and completing a postsecondary STEM major or degree), particularly for Hispanic students. The review found that courses taken in high school and interest or confidence in STEM were strong predictors of postsecondary STEM success for students of all racial/ethnic subgroups. Yet racial/ethnic minority students were less likely than White students to take the highest level math and science courses, and despite similar levels of STEM interest, racial/ethnic minority students were less likely to achieve postsecondary STEM success. Other indicators of postsecondary STEM success included high school grade point average, class rank, math and science achievement, and SAT or ACT scores. Grades in math and science courses were found to be less predictive of postsecondary STEM success for racial/ethnic minority students than for White students.

This brief summarizes the findings of Hinojosa, T., Rapaport, A., Jaciw, A., LiCalsi, C., & Zacamy, J. (2016). Exploring the foundations of the future STEM workforce: K–12 indicators of postsecondary STEM success (REL 2016–122). Washington, DC: U.S. Department of Education, Institute of Education Sciences, National Center for Education Evaluation and Regional Assistance, Regional Educational Laboratory Southwest. That report is available at http://ies.ed.gov/ncee/edlabs/projects/project.asp?ProjectID=406.

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Why this review?

The number of jobs in science, technology, engineering, and math (STEM) is projected to grow substantially in the coming years (Vilorio, 2014). However, the United States faces a major challenge in attracting, preparing, and employing a qualified workforce to fill STEM jobs (Jobs for the Future, 2007).

With considerable shifts in the demographic composition of the country, an increasing share 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 careers (Beede et al., 2011). Such underrepresentation may subsequently affect equitable access to jobs in STEM fields and the sustainability of the STEM workforce in general. The underrepresentation of Hispanic people in the STEM workforce may be explained in part by differences in the STEM knowledge and motivation that is instilled into Hispanic students in grades K–12. The disparities in Hispanic students' education experiences may reduce their likelihood of pursuing a STEM degree and career.

Regional Educational Laboratory (REL) Southwest conducted a systematic review of the research literature to identify K–12 indicators that are significant predictors of postsecondary STEM success, particularly for Hispanic students. The goal of the review was to provide information that helps policymakers, district and school leaders, and researchers develop and implement interventions that increase the percentage of Hispanic students who succeed in STEM education and pursue STEM careers. This brief summarizes the results of this review; box 1 describes the data and methods used in the review.

Box 1. Data and methods

The review addressed two research questions:

- What K–12 indicators predict postsecondary science, technology, engineering, and math (STEM) success?
- To what extent do K–12 indicators of postsecondary STEM success differ for Hispanic and non-Hispanic students?

Postsecondary STEM success was defined as enrolling in, persisting in, and completing a postsecondary STEM degree. STEM fields were defined as majors in computer and information sciences, engineering and engineering technologies, biological and biomedical sciences, math and statistics, physical sciences, and science technologies.

Studies were considered relevant for the review if they met all of 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.

A database search identified 600 journal articles that included the keywords that the research team developed. When these 600 articles' abstracts were screened against the review criteria, 43 passed the criteria for inclusion. Of these, 21 articles addressed one of the review's two original research questions. Two additional studies met the criteria but examined STEM career as the outcome. These studies were included in the review because the careers included in these studies required a postsecondary STEM degree.

The final number of studies included in the review was 23. Twenty-two of these studies were correlational in nature; they examined the relationship between K–12 indicators and postsecondary STEM outcomes but did not contain information on the causal role of the indicators. One study was experimental.

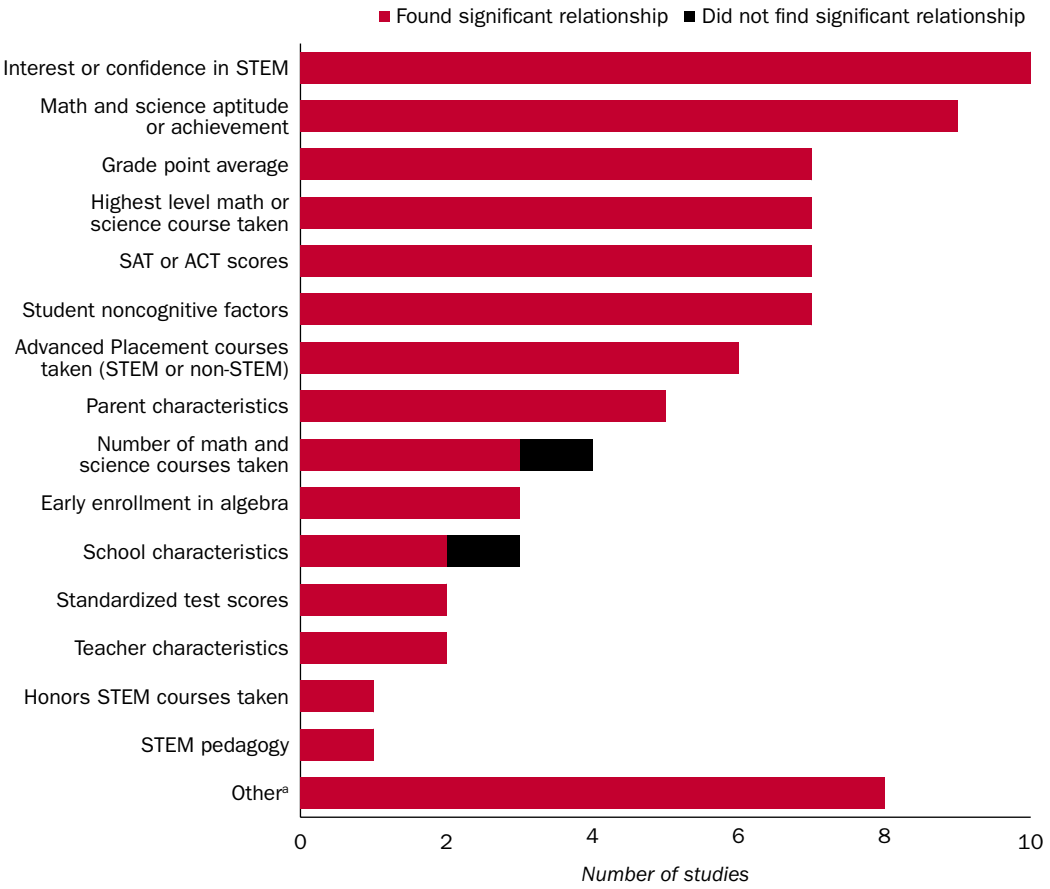
What the review found

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 and interest or confidence in STEM 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 included 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 STEM courses taken (1 study; figure 1). The second most frequently examined indicator was student interest or confidence in 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

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 studies. 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.

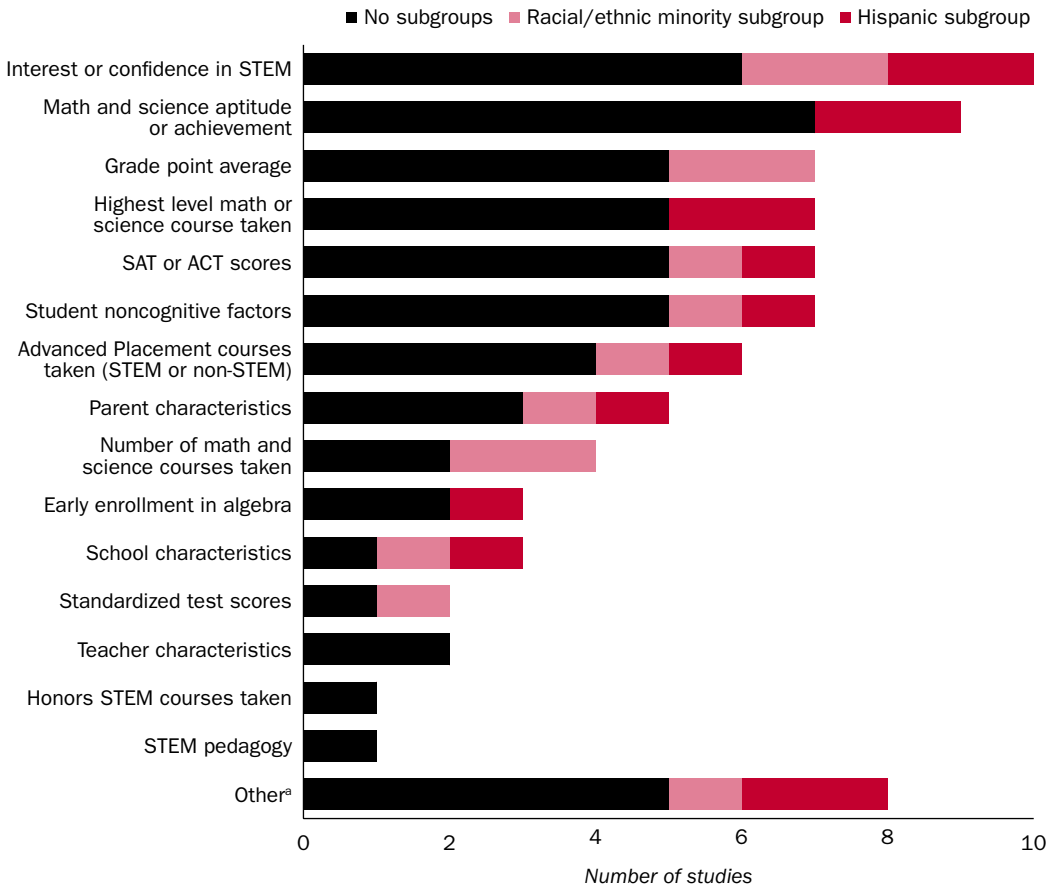
Source: Authors' compilation based on the studies reviewed.

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).

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

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.

The number of math and science courses taken and the rigor (or level) of those courses predict postsecondary STEM success

The number of math and science courses taken during high school was a strong predictor of pursuing a STEM major. However, the indicator performed strongest for White students and weakest for racial/ethnic minority students.

When the rigor of courses was considered, the highest level math or science course taken in high school (for example, calculus or Advanced Placement STEM courses) was most predictive of pursuing a STEM major across races/ethnicities and genders. But despite receiving more high school math credits than White students did, Black and Hispanic students were generally less likely to take higher level courses (the types of courses that strongly predict postsecondary STEM success).

Interest or confidence in STEM predicts postsecondary STEM success

All studies that examined the relationship between interest or confidence in STEM (starting as early as grade 7) and postsecondary STEM success found a statistically significant positive relationship. However, measures of interest or confidence in STEM in K–12 were less predictive of later STEM outcomes than were math and science courses taken.

Racial/ethnic minority students, including Hispanic students, reported attitudes and confidence toward STEM in K–12 similar to those of White students. Furthermore, attitudes toward STEM were similarly predictive of pursuing a STEM major for White and racial/ethnic minority students. Despite these similarities, racial/ethnic minority students were less likely to pursue a STEM major than were White students with similar attitudes toward STEM.

Overall K–12 achievement predicts postsecondary STEM success

Various indicators of high school achievement, including high school grade point average, class rank (indicator classified as "other"), and high school math and science achievement, were also found to be predictors of postsecondary STEM success. Grades in high school math and science courses were less predictive of pursuing a STEM major for racial/ethnic minority students than for White students. Differences in the average rigor of the courses taken between racial/ethnic minority and White students may help explain this finding.

SAT and ACT math scores and non-STEM courses taken and ability predict postsecondary STEM success

Students with higher SAT or ACT math scores were more likely to achieve postsecondary STEM success. However, for students with the same SAT or ACT math score, the higher their verbal score, the less likely they were to pursue or complete a postsecondary STEM degree. Similarly, holding the number of Advanced Placement STEM courses taken constant, the percentage and number of Advanced Placement non-STEM courses taken in high school were negatively related to pursuing a STEM major and completing a STEM degree. These results suggest that students who excel in other subjects in addition to STEM are less likely to pursue a postsecondary STEM degree. None of the studies that examined SAT or ACT scores or non-STEM courses taken compared outcomes between Hispanic and non-Hispanic students.

Additional predictors of postsecondary STEM success include school-, classroom-, and teacher-level characteristics; parent attitudes; student non-STEM noncognitive factors; and extracurricular activities

Across studies, a number of additional indicators of postsecondary STEM success emerged.

School-, classroom-, and teacher-level characteristics. Studies that examined the relationship between school- or teacher-level characteristics (for example, the proportion of students enrolled in a college preparatory program, students' satisfaction with their teachers, the extent to which students received academic and career guidance, students' ratings of the school's overall learning environment, teacher use of hands-on materials, and extent of lecturing) and postsecondary STEM success found mixed results. The one experimental study that explored the association between class size (indicator classified as "other") and STEM success found a causal relationship: a smaller class size in grades K–3 increased the rate of completing a postsecondary STEM degree. The effect was stronger for Black students and students attending poor schools. None of the studies explored whether the relationship between school-, classroom-, or teacher-level characteristics and postsecondary STEM success differed for Hispanic students.

Parent attitudes. Parent encouragement of math and science learning in high school and parent expectations related to the length of their children's education were predictive of pursuing a STEM major. The studies that examined the relationship between parent attitudes and students' postsecondary STEM success did not explore subgroup differences based on race/ethnicity.

Student non-STEM noncognitive factors. Students who saw themselves going further in school were more likely to pursue a STEM major. Among adolescents who put a high priority on parenthood, men were three times more likely than women to complete a STEM degree; however, there were no differences by gender for adolescents who did not put a high priority on parenthood. The studies did not explore subgroup differences based on race/ethnicity.

Extracurricular activities. Participation in a math club but not a science club predicted pursuing a STEM major after differences between students who did and did not participate in math and science clubs (for example, demographics and prior achievement) were controlled for (indicator classified as "other"). These findings were similar for all subgroups of students regardless of race/ethnicity.

Implications of the review findings

The studies in the review have important implications for both research and practice related to preparing students for postsecondary STEM pursuits. However, although some indicators were found to be significantly related to postsecondary STEM success, in all but one case the studies were not designed to determine whether a causal relationship exists between a K–12 indicator and a postsecondary STEM outcome.

The rigor or level of STEM courses taken predicts postsecondary STEM success, but Hispanic students are less likely to take higher level STEM courses

The rigor or level of math and science courses taken in high school was the strongest predictor of postsecondary STEM success for students of all races/ethnicities, but Hispanic and other racial/ethnic minority students take less rigorous math and science courses than White students do. Future research could test whether purposely increasing the rigor of the math and science courses that racial/ethnic minority students take results in better postsecondary STEM outcomes.

Despite similar interest and positive attitudes toward STEM, Hispanic students are less likely to pursue a STEM major and complete a postsecondary STEM degree

Positive attitudes and interest in STEM, starting as early as middle school, were significant predictors of pursuing a STEM major across races/ethnicities and genders. However, these measures did not explain disparities in postsecondary STEM success between subgroups of students. 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.

Few studies examined the predictive power of indicators for Hispanic students specifically

Only 4 of 23 studies specifically examined indicators of STEM success for Hispanic students, and those studies did not examine differences within Hispanic populations (for example, whether differences exist between Hispanic students who are and those who are not economically disadvantaged or those who have and those who do not have limited English proficiency). More research on differences by student subgroup and within Hispanic subgroups will help reveal ways in which K–12 indicators vary in their predictive powers relative to postsecondary STEM success.

Limitations of the review findings

A primary limitation of this review is that 22 of the 23 reviewed studies were correlational in nature and thus cannot be used to infer causality. Additional research is needed to examine the presence of a causal relationship between identified significant indicators (for example, taking high-level math and science courses in high school) and desired STEM outcomes and to suggest interventions with more confidence.

In addition, 19 of the 23 reviewed studies were based on a sample of students enrolled in a four-year college, excluding students who did not graduate high school or never enrolled in college. More research is needed to explore the predictive power of K–12 indicators of postsecondary STEM success when all students are included.

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