RTI Press

Research Report

March 2016

The Role of STEM High Schools in Reducing Gaps in Science and Mathematics Coursetaking: Evidence from North Carolina

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RTI Press publication RR-0025-1603

Suggested Citation

Glennie, E., Mason, M., and Dalton, B. (2016). *The Role of STEM High Schools in Reducing Gaps in Science and Mathematics Coursetaking: Evidence from North Carolina*. RTI Press Publication No. RR-0025-1603. Research Triangle Park, NC: RTI Press. http://dx.doi.org/10.3768/rtipress.2016.rr.0025.1603

This publication is part of the RTI Press Research Reports series.

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Acknowledgments

Funding for this study was provided by the National Science Foundation, Grant No. 1135051 and RTI International. Authors are grateful for that support and for the assistance and advice of Julie Edmunds and Erich Lauff.

Abstract

Some states have created science, technology, engineering, and mathematics (STEM) schools to encourage student interest and enhance student proficiency in STEM subjects. We examined a set of STEM schools serving disadvantaged students to see whether these students were more likely to take and pass advanced science and mathematics classes than their peers in traditional schools. Although some gaps in STEM coursetaking persist, economically disadvantaged and underrepresented minority students in STEM schools are more likely to take and pass these classes than their peers in non-STEM schools. Compared with non-STEM schools, the STEM schools have smaller gaps in advanced science and mathematics coursetaking and passing between disadvantaged and nondisadvantaged students.

Introduction

A solid grounding in science, technology, engineering, and mathematics (STEM) can prepare students for emerging opportunities in the workforce. In 2010, the US Department of Labor projected that 26 of the 30 fastest-growing occupations for 2018 will require preparation in the STEM fields, and 14 of them will require a bachelor's degree or higher (Lacey & Wright, 2010). However, among US college students, degree completion in the STEM fields is half of what it was in 1960 (US Government Accountability Office, 2006). In 2010, only 16 percent of undergraduate degrees in the United States were in STEM-related fields, placing the nation far behind the international community (e.g., 64 percent of undergraduates degrees in Japan were in STEM fields) (US Department of Education, 2010). Some students graduate from high school unprepared for the rigors of postsecondary coursework in the STEM disciplines, which makes it more difficult to complete a postsecondary degree in a STEM field. According to national data from ACT, which administers a national college entrance exam, of the high school graduating class of 2008, only 43 percent of ACT-tested students were ready for college-level mathematics, and only 29 percent of ACT-tested students were ready for college-level science (ACT, Inc., 2010).

Policy makers are concerned not only about overall challenges in preparing students for college study and careers in STEM, but also about some groups of students being less likely than others to take STEM classes that will help prepare them for STEM college work and careers. Overall, taking more college preparatory mathematics and science courses helps students prepare for postsecondary work. For example, participants in the pre-engineering Project Lead the Way (PLTW) program who had completed 4 years of college preparatory mathematics had better scores on a National Assessment of Educational Progress (NAEP)–referenced mathematics assessment than PLTW students who had taken fewer such courses. Similarly, PLTW students who had completed 4 years of college preparatory science had better scores on a science assessment (Bottoms & Anthony, 2005). However, although all racial and ethnic groups have increased their participation in advanced mathematics in recent years, white and Asian students are consistently more likely than black, Hispanic, and American Indian students to take these courses. Likewise, science and mathematics coursetaking gaps between students in the highest and lowest quartiles of socioeconomic status have persisted for decades (Dalton, Ingels, Downing, & Bozick, 2007). A longitudinal study of students in Florida found that, among those who entered college, black students were less likely to be ready for college mathematics than their white counterparts. Although middle school achievement explains some of this difference, courses taken in high school influence the likelihood of readiness; taking algebra II, precalculus, and calculus each increase the likelihood of being ready for college mathematics (Long, Iatarola, & Conger, 2009). Another study found that black and Hispanic students complete lower level high school courses than whites; however, black and Hispanic students who did take high-level courses were as likely as white students to pursue STEM degrees (Tyson, Lee, Borman, & Hanson, 2007).

In response to this growing need for a STEM-focused education, states have been successful in encouraging students to take more courses in science and mathematics in high school (Shettle et al., 2007). A higher percentage of high school graduates took advanced mathematics and science classes in 2009 than in 2005, which continued a trend that began in the 1990s. In 1990, 53 percent of high school graduates had taken algebra II compared with 76 percent in 2009 (Nord et al., 2011). Some states have also created or supported the establishment of separate STEM high schools to encourage students to embark on programs of STEM study. These schools have a programmatic focus on one or more subject areas in STEM and may follow specific design principles or use less common teaching methods to promote subject matter engagement (National Research Council, 2011; North Carolina New Schools, 2014).

To examine whether STEM high schools hold the promise of increasing STEM coursetaking and reducing gaps in coursetaking between disadvantaged and advantaged groups, this paper examines the patterns of STEM course enrollment and passing

RTI Press Publication No. RR-0025-1603. Research Triangle Park, NC: RTI Press. http://dx.doi.org/10.3768/rtipress.2016.rr.0025.1603

among a set of STEM high schools in North Carolina. These schools, part of a network supported by the North Carolina New Schools (NCNS) nonprofit organization, can be newly established schools or redesigned schools in which educators transform an academically struggling traditional high school into a smaller, more academically engaging school. In 2011–2012, North Carolina had 21 NCNS STEM schools, designed to promote STEM learning through a variety of engaging, relevant approaches to instruction (NCNS, 2013a). We examined whether underserved students in North Carolina STEM high schools have similar or higher rates of advanced science and mathematics coursetaking than students in neighboring traditional high schools. Specifically, we asked:

1. Do students who are eligible for free or reduced-price lunch in STEM schools take and pass advanced science and mathematics classes at similar or higher rates than their peers in traditional schools?
2. Do underrepresented minority group students in STEM schools take and pass advanced science and mathematics courses at similar or higher rates than their peers in traditional schools?
3. Do STEM schools have smaller within-school gaps in advanced science and mathematics coursetaking and passing by poverty and race/ethnicity than traditional schools?

The first two questions compare coursetaking patterns between STEM and traditional high schools, whereas the third question examines differences in coursetaking and passing by groups within STEM schools and within traditional schools.

The Impact of STEM High Schools

Although traditional schools can increase the emphasis on STEM, some states have created separate STEM high schools to encourage and support students in taking STEM courses. These schools may be selective or inclusive (National Research Council, 2011). Selective STEM schools have admissions criteria and serve highly talented, motivated students with advanced curricula, sophisticated laboratory equipment, and professional development opportunities for teachers. Inclusive STEM schools do not have selective admissions criteria and may target underserved students, believing that with appropriate opportunities, students can develop STEM skills. STEM career and technical education schools focus on preparing students for STEM careers with a goal of increasing engagement to prevent students from dropping out. Even with these newly created schools, a comparison of STEM schools with neighboring traditional schools found that STEM high schools tended to have fewer students from disadvantaged groups than their district averages (Rogers-Chapman, 2013).

Given that some STEM schools are selective and some are inclusive, and that they have different educational approaches, it is difficult to evaluate the overall impact of STEM or the extent to which STEM schools mitigate STEM competency gaps. In a review of the STEM literature, Subotnik, Tai, Rickoff, and Almarode (2010) noted that no studies provided comprehensive analyses of the contribution that these schools make over and above traditional high schools.

However, some research suggests STEM schools do benefit students overall, as well as ethnic and racial minority and economically disadvantaged students who are underrepresented in STEM. Across STEM schools in New York City, including highly selective schools, the mathematics and science test score achievement gaps between blacks and whites and between Hispanics and whites were smaller than in traditional schools (Wiswall, Stiefel, Schwartz, & Boccardo, 2014). A comparative case study of inclusive STEM schools found that these schools focused on more rigorous course requirements and real-world problem solving and that students who attended STEM-focused high schools outperformed their peers (Scott, 2012). A study of inclusive STEM schools in Texas found that students in that state's 51 inclusive STEM schools scored slightly higher on the state mathematics and science achievement tests, were less likely to be absent from school, and took more advanced courses than their peers in comparison schools (Young, House, Wang, Singleton, & Klopfenstein, 2011).

STEM schools may incorporate more rigorous mathematics and science standards and include more instruction time for STEM classes. However, many recognize that success in STEM education requires changing the way that teachers deliver STEM instruction. Effective instruction that gives students opportunities to participate in STEM practices helps them to engage and identify with STEM subjects (National Research Council, 2011). Creativity strategies and learning through design are particularly effective for reinforcing STEM-based material (Clark & Ernst, 2007). Problem-based and project-based approaches to student learning have been shown to improve the understanding of basic concepts and to encourage deep and creative learning no matter the academic content area (Powers & DeWaters, 2004).

Evaluations of STEM curricular practices have shown benefits to some kinds of instruction across a variety of school and program models. The PLTW pre-engineering program focuses on project-based learning and real-world applications of knowledge. PLTW students took more mathematics classes and scored higher on assessments than a randomly selected control group did (Bottoms & Anthony, 2005). In a survey, teachers in a STEM-focused New Tech high school reported that they thought that project-based learning and integrating materials across subject areas is crucial to success in STEM education (Gourgery, Asiabanpour, & Crawford, 2009). A longitudinal study of North Carolina middle school students found integrating technology into the classroom and in-class project-based learning were associated with gains in mathematics and science, while real-world learning and applying mathematics to other subjects was associated with small gains in mathematics (Hansen & Gonzalez, 2014). A longitudinal, nationally representative study of the influence of STEM instructional practices in secondary school found that using hands-on materials in mathematics was positively related to students subsequently pursuing a degree in a STEM field, whereas those who reported frequent use of computers in mathematics were less likely to earn STEM degrees. In science, students who reported more lecturing by their teacher and frequent book use to learn how experiments should be run were less likely to go on to receive STEM degrees (Maltese & Tai, 2011).

Responding to STEM Demand in North Carolina

As in the nation as a whole, STEM education in North Carolina is critical for preparing the workforce for future opportunities. By 2018, three-fifths of the jobs in North Carolina will require postsecondary education, and one-fifth of the jobs requiring some college will require a concentration in a STEM discipline (Center on Education and the Workforce, 2010). Furthermore, North Carolina sees gaps among different types of students' STEM achievement.

In North Carolina's 2011 NAEP eighth-grade science assessment, black students' average score was 34 points lower than the score for white students, and Hispanic students' average was 22 points lower than that of white students. Students eligible for free or reduced-price lunch had an average score that was 24 points lower than that for those not eligible for free or reduced-price lunch (National Center for Education Statistics [NCES], 2012). Similarly, in the mathematics assessment, black students' average score was 28 points lower than that of white students, whereas Hispanic students' average score was 17 points lower than that of white students. The average score for students who were eligible for free or reduced-price lunch was 25 points lower than that of those not eligible for free or reduced-price lunch (NCES, 2014).

Fortunately, North Carolina students have made great strides in preparing for college studies and careers in STEM. According to 1999 Trends in International Mathematics and Science Study (TIMSS) data, North Carolina's mathematics and science scale scores were below the US average (Mullis et al., 2001). By 2011, the average mathematics and science scores of North Carolina's eighth graders were above the TIMSS US averages (NCES, 2013). NAEP results show similar improvements in mathematics. In 1990, 9 percent of North Carolina's eighth graders performed at or above NAEP's proficient level in mathematics, whereas in 2013, 36 percent of North Carolina eighth graders were proficient in mathematics (NCES, 2014).

Some of North Carolina's advancement may result from educators and policy makers working to develop new schools to meet the demand for STEM preparation. The North Carolina Department of Public Instruction (NCDPI), higher education partners, and local educators have created more than 100 innovative STEM high schools across the state. In 2011, North Carolina STEM schools were more likely than traditional schools to serve black students and poor students, and they were more likely to be located in rural areas (Corn, Stallings, Arshavsky, & Parker, 2011). This outcome may reflect the state's emphasis on enhancing educational experiences for students who are underrepresented in college. Some schools work with partners such as NCNS, PLTW, and North Carolina's Career Academies. With support from the Bill and Melinda Gates Foundation and the North Carolina General Assembly, the NCNS effort has been particularly strong.

We focus specifically on inclusive STEM schools that are partners with NCNS. NCNS schools can be newly established schools or redesigned schools in which educators transform an academically struggling traditional high school into a smaller, more academically nimble school to better serve students. In a newly established school, a district might decide to partner with NCNS and have a school use this model. For a redesigned school, the state identifies low-performing schools that need to make curricular changes. School leaders and teachers in a redesigned NCNS school adopt a theme, such as STEM. In some schools, students may apply to attend, as they would in a magnet school. Districts determine the application process, which could include a lottery; otherwise, students may be assigned to attend.

Schools affiliated with NCNS share consistent design principles and goals and are designed to be small, with a maximum of 100 students per grade. In 2011–2012, North Carolina had 21 NCNS STEM schools designed to function as laboratories for students to solve real-world problems, emphasize connections in the fields of mathematics and science, integrate technology into classrooms, support teachers, and promote out-of-school learning in cocurricular activities (NCNS, 2013a). By fostering a schoolwide focus on STEM, NCNS hopes to bolster student motivation in and understanding of complex STEM content.

Each NCNS school implements these goals by adopting specific goals and practices for teachers and other school staff:

1. *Ensure that students are ready for college* by maintaining a common set of high standards for every student.
2. *Instill powerful teaching and learning in schools* by designing rigorous instruction that fosters the development of critical thinking and problem-solving skills.
3. *Redefine professionalism* by having a collaborative work orientation and a commitment to improving the capacity of staff.
4. *Foster shared leadership* by developing a shared mission for their school and share leadership for improved student outcomes.
5. *Personalize educational resources* by knowing students well enough to help them achieve academically.
6. *Implement a purposeful design* by allocating resources so best practices become common practice (NCNS, 2013b).

All students should take college preparatory classes and are expected to graduate from high school ready for college and careers; however, they are not required to take advanced mathematics or science classes. With a schoolwide focus on STEM, the instructional practices in STEM classes should emphasize problem-based and project-based approaches to student learning, and schools should not have gaps in student preparation for and motivation to take advanced science and mathematics courses.

Methods

Study participants are 11,419 students enrolled in 21 NCNS STEM high schools and 58,949 students enrolled in 43 neighboring high schools in 2011–2012. We provide descriptive analyses of coursetaking for students from STEM and non-STEM schools overall and by free or reduced-price lunch eligibility status and underrepresented minority status (underrepresented minorities include black, Hispanic, and American Indian students). First, we examine differences between students in STEM schools and those in non-STEM schools in the percentage who took advanced science and mathematics courses, and then differences in the percentage who passed these courses. Passing is defined as receiving a grade of A, B, C, D, Satisfactory, or Passed. We used two-proportion z-tests to determine whether differences in proportions (e.g., percentage passing advanced science courses) between the STEM schools and non-STEM schools were statistically significant. To test whether differences in mean values (e.g., average test scores) were statistically significant, the Wilcoxon Mann-Whitney test was used. The Wilcoxon test is valid for distributions that are not normal and is less sensitive to outliers than a two-sample t-test.

Data employed come from the administrative student data collected by NCDPI and made available to qualified researchers through the North Carolina Education Research Data Center at Duke University. These files provide demographic and transcript data for all students in North Carolina public schools. We focus on the 2011–2012 school year identifying STEM schools based on the list of NCNS STEM schools during the 2011–2012 academic year.[1]

[1] List of NCNS STEM schools retrieved from http://ncnewschools.org (accessed September 2014).

Using data from the NCES Common Core of Data Public School Universe and data from North Carolina's School Report Card, we identified comparison schools, which are traditional schools within the same districts as STEM schools. Some districts do not have any traditional high schools, or schools that are not charter schools, magnet schools, or otherwise affiliated with a partner like NCNS. In such cases, we included traditional schools in the neighboring districts. Students within the same district or a neighboring district have similar STEM educational and employment opportunities in their geographic area and may thus have similar motivations to pursue STEM.

To select a neighboring district, we chose the one that was most comparable in terms of student demographics, urbanicity, and average number of high school students, student academic performance and teacher qualifications including turnover rate, novice status, licensure status, and National Board certification status. Table 1 presents the characteristics of the students and teachers in the STEM and non-STEM schools.

Table 1. Average characteristics of STEM and neighbor traditional schools

Characteristic	STEM schools			Neighbor traditional schools			Difference in mean value
	N	Mean	STD	N	Mean	STD	
Number of students	21	575.8	489.8	43	1,404.9	719.4	-829.1*
Percent free or reduced price lunch and underrepresented minority	21	46.1	49.8	43	34.0	47.7	12.1
Percent free or reduced-price lunch (not underrepresented minority)	21	18.5	38.8	43	11.8	32.3	6.6
Percent underrepresented minority (not free or reduced-price lunch)	21	7.0	25.5	43	10.7	31.0	-3.8
Graduation rate	21	82.0	6.2	42	83.4	8.4	-1.4
Percent SAT participation	19	60.4	15.8	41	69.4	15.6	-9.0
Average SAT score	19	898.0	92.5	41	972.8	109.5	-71.0*
Percent of schools that made at least expected growth and had at least 80% of its students' scores at or above grade level	21	28.6	46.3	42	45.2	50.4	-16.6
Teacher turnover rate	21	18.1	6.8	43	14.5	11.1	3.6
Percent novice teachers	21	23.7	6.2	43	19.1	11.4	4.6
Percent teachers fully licensed	21	89.8	4.9	43	95.7	9.9	-5.9
Percent teachers National Board Certified	17	12.5	7.5	41	19.6	6.7	-7.1

* $p < .01$

Sources: National Center for Education Statistics' Common Core Data and North Carolina School Report Card Data, 2011–2012; and North Carolina Department of Public Instruction administrative data, 2011–2012.

Using transcript data, we defined STEM courses using North Carolina's state course codes and course titles to identify relevant courses. We then categorized them as advanced based on NCES definitions used in the High School Transcript Studies of the NAEP and in secondary longitudinal studies such as the Education Longitudinal Study of 2002 (see, e.g., Dalton et al., 2007). We adapted this list for the smaller number of courses included in the North Carolina database. Advanced mathematics courses include calculus, precalculus, and other advanced mathematics such as algebra III and probability or statistics. Advanced science courses include second-year chemistry or physics and advanced biology. For both mathematics and science, any Advanced Placement (AP) or International Baccalaureate (IB) course was also classified as advanced. (The appendix contains lists of advanced courses in each subject.)

Results

Characteristics of STEM and Non-STEM Student Populations

STEM schools served fewer students, on average, than non-STEM schools in 2011–2012 (576 students compared with 1,405 students) (Table 1). This is not surprising because NCNS schools are designed to be smaller schools, with no more than 100 students in each grade level. Scores on the SAT college entrance exam were lower in STEM schools than in non-STEM schools (898 compared with 973). These were the only differences that were statistically significant.

Although the remaining differences were not statistically significant, STEM schools served a higher percentage of students who were both underrepresented minorities and eligible for free or reduced-price lunch (46 percent vs. 34 percent) than non-STEM schools. A higher percentage of STEM schools had lower ratings in North Carolina's accountability system. Although 29 percent of the STEM schools made expected growth and had at least 80 percent of students performing at grade level, 45 percent of non-STEM schools made this goal. Although student body poverty level and levels of student achievement affect the likelihood that a school will retain qualified teachers (see e.g., American Association of State Colleges and Universities, 2005; Ingersoll, 2002; Newton, Rivero, Fuller, & Dauter, 2011), STEM and non-STEM schools did not statistically differ on any of the teacher characteristics.

Comparison of Coursetaking Between Students in STEM Schools and Those in Non-STEM Schools

Our analyses compare students in STEM schools with those in non-STEM schools, overall and by student subgroups, on advanced science and advanced mathematics coursetaking and course passing during the 2011–2012 academic year. Because coursetaking is cumulative, examining outcomes from one point in time can produce smaller differences between the groups than examining outcomes that are measured across the high school career. As a result, many of the differences found in these analyses were relatively small. Also, the analyses examined the combined results of all students (grades 9 through 12) in the STEM and non-STEM schools. All findings discussed are statistically significant, unless otherwise noted.

Because mathematics knowledge in early grades predicts mathematics achievement in high school (Seigler et al., 2012), we compared the average end-of-grade science and mathematics test scores of eighth-grade students who subsequently attended STEM schools to those of students who subsequently did not attend STEM schools. Almost all students take these standardized assessments as part of North Carolina's accountability system.

We found that among eighth-grade students, those who subsequently enrolled in STEM schools had slightly lower scores on both of these tests. The average science test score was 152 for students who enrolled in STEM schools and 154 for those enrolled in non-STEM schools, whereas the average mathematics test score was 363 for students who enrolled in STEM schools and 364 for those who did not enroll in STEM schools (Table 2).

Because the STEM schools in our sample are more likely to serve students who have lower levels of achievement in eighth grade, are economically disadvantaged, and are members of an under-represented minority group, students in these STEM schools, on average, would be expected to have lower levels of participation and success in advanced courses. Therefore, a finding that students in STEM schools are as likely as students in non-STEM schools to take and pass advanced science and mathematics courses would suggest that these students benefit from attending STEM schools.

Overall Differences Between STEM and Non-STEM Schools

Overall, students in STEM schools and those in non-STEM schools did not differ in advanced science coursetaking. However, students in STEM schools were slightly less likely to take an advanced mathematics course than their peers (23 percent vs. 25 percent, respectively) (Table 3). In STEM and non-STEM schools, students who took advanced science and mathematics courses typically passed them. However, students in STEM schools who took an advanced course were more likely to pass the course. Of those taking advanced science courses, 98 percent of students in STEM schools passed, compared with 95 percent of their peers in non-STEM schools. In STEM schools, 98 percent of students who took advanced mathematics courses passed, compared with 97 percent of students in non-STEM schools.

Research Question 1:

Do students who are eligible for free or reduced-price lunch in STEM schools take and pass advanced science and mathematics classes at similar or higher rates than their peers in traditional schools?

Students who were eligible for free or reduced-price lunch in STEM schools were more likely to take advanced science and mathematics courses than their peers who attended non-STEM schools (Table 4). Of students eligible for free or reduced-price lunch in STEM schools, 5 percent took an advanced science course, and 18 percent took an advanced mathematics course. In contrast, 4 percent of students eligible for free or reduced-price lunch in traditional schools took an advanced science course, and 15 percent took advanced mathematics courses. Students eligible for

Table 2. End-of-grade-8 science and mathematics test results for students in STEM and non-STEM schools

Characteristic	Range		Students in STEM schools			Students in non-STEM schools			Difference in mean value
	Min	Max	N	Mean	STD	N	Mean	STD	
Average end-of-grade-8 science achievement test score	123	180	9,611	151.9	8.4	48,295	154.1	9.1	-2.2*
Average end-of-grade-8 mathematics achievement test score	334	386	9,741	362.5	7.8	49,039	363.9	8.7	-1.4*

* $p < .01$

Source: North Carolina Department of Public Instruction administrative data, 2006–2007 through 2011–2012.

Table 3. Percentage of students in STEM and non-STEM schools who took and passed advanced science and mathematics courses

Student group	Total	Coursetaking		Course passing	
		Advanced science	Advanced math	Advanced science	Advanced math
STEM	11,419	6.5	22.7	97.8	98.1
Non-STEM	58,949	6.5	24.8	95.1	96.6
Difference (STEM – Non-STEM)		**-0.1**	**-2.2***	**2.7***	**1.5***

* $p < .01$

Source: North Carolina Department of Public Instruction administrative data, 2011–2012.

http://dx.doi.org/10.3768/rtipress.2016.rr.0025.1603

Table 4. Percentage of students in STEM and non-STEM schools who took and passed advanced science and mathematics courses by free or reduced-price lunch eligibility: 2011–2012

Free or reduced-price lunch eligibility	Total	Coursetaking		Course passing	
		Advanced science	Advanced math	Advanced science	Advanced math
Free or reduced-price lunch					
STEM	7,368	4.7	18.1	98.3	97.8
Non-STEM	27,015	3.8	14.6	86.8	94.1
Difference (STEM – Non-STEM)	**—**	**0.9***	**3.4***	**11.5***	**3.7***
Not free or reduced-price lunch					
STEM	4,051	9.7	31.0	97.5	98.5
Non-STEM	31,934	8.9	33.4	98.2	97.5
Difference (STEM – Non-STEM)	**—**	**0.9**	**-2.5***	**-0.7***	**1.0***

* $p < .01$

Source: North Carolina Department of Public Instruction administrative data, 2011–2012.

free or reduced-price lunch in STEM schools who took advanced science or mathematics courses were more likely to pass the courses than their non-STEM peers. Of these economically disadvantaged students, about 12 percent more STEM advanced science coursetakers passed the course than their non-STEM peers, and about 4 percent more STEM advanced mathematics coursetakers passed than their non-STEM peers. In sum, students who were eligible for free or reduced-price lunch in STEM schools were more likely to take and pass advanced science and mathematics classes than their peers in non-STEM schools.

Among those who were not eligible for free or reduced-price lunch, differences between students in STEM schools and those in traditional schools are less striking, suggesting that this model has a weaker effect on them. Economically advantaged students did not differ in their advanced science coursetaking, but those in STEM schools were less likely to take advanced mathematics courses. Of economically advantaged students who took advanced courses, students in STEM schools were slightly less likely to pass an advanced science course than peers in non-STEM schools, but slightly more likely to pass an advanced mathematics course.

Research Question 2:

Do underrepresented minority group students in STEM schools take and pass advanced science and mathematics courses at similar or higher rates than their peers in traditional schools?

Among students in STEM schools who were members of underrepresented minority groups, 6 percent took an advanced science class and 21 percent took an advanced mathematics class (Table 5). In traditional schools, 4 percent of students in underrepresented minority groups took an advanced science class and 16 percent took an advanced mathematics course. Of those who took advanced classes, 98 percent in STEM schools passed advanced science and advanced mathematics courses, compared with 89 percent of students in advanced science and 95 percent in advanced mathematics in traditional schools.

Students who were not members of underrepresented minority groups did not differ in advanced science coursetaking between STEM and traditional schools (about 8 percent), but students in STEM schools who were not members of underrepresented minority groups were less likely to take advanced mathematics than their peers in non-STEM schools (25 percent vs. 32 percent). For those students who took advanced courses, students in STEM schools did not differ from peers in traditional schools in passing advanced

Table 5. Percentage of students in STEM and non-STEM schools who took and passed advanced science and mathematics courses by underrepresented minority status

Underrepresented minority status	Total	Coursetaking		Course passing	
		Advanced science	Advanced math	Advanced science	Advanced math
Underrepresented minority					
STEM	6,058	5.5	20.6	97.9	98.0
Non-STEM	26,378	4.2	16.4	89.4	94.8
Difference (STEM – Non-STEM)	—	**1.2***	**4.2***	**8.5***	**3.2***
Not underrepresented minority					
STEM	5,361	7.6	25.0	97.8	98.3
Non-STEM	32,571	8.4	31.6	97.4	97.3
Difference (STEM – Non-STEM)	—	**-0.8**	**-6.6***	**-0.3**	**0.9***

* $p < .01$

Source: North Carolina Department of Public Instruction administrative data, 2011–2012.

science classes, but they were slightly more likely to pass advanced mathematics classes (98 percent vs. 97 percent, respectively).

In STEM and non-STEM schools, students who were economically disadvantaged and not underrepresented minorities had higher rates of taking and passing advanced science and mathematics courses than those who are usually less likely to take advanced courses (economically disadvantaged, underrepresented minority). However, students in STEM schools who were economically disadvantaged or in the underrepresented minority group were more likely to take and pass advanced science and mathematics classes than their non-STEM peers were. The influence of STEM schools on coursetaking for students who were not economically disadvantaged and those not in the underrepresented minority group were mixed. Next, we examine how these group differences in coursetaking and course passing affect the size of gaps between STEM and non-STEM schools.

Research Question 3:

Do STEM schools have smaller within-school gaps in advanced science and mathematics coursetaking and passing by poverty and race/ethnicity than traditional schools?

The previous questions examined differences between school types in coursetaking and passing to show, for example, whether more free or reduced-price eligible students in STEM schools take and pass advanced courses than their peers in traditional schools. Here, we focus on whether group coursetaking gaps are smaller in STEM schools than in traditional schools.

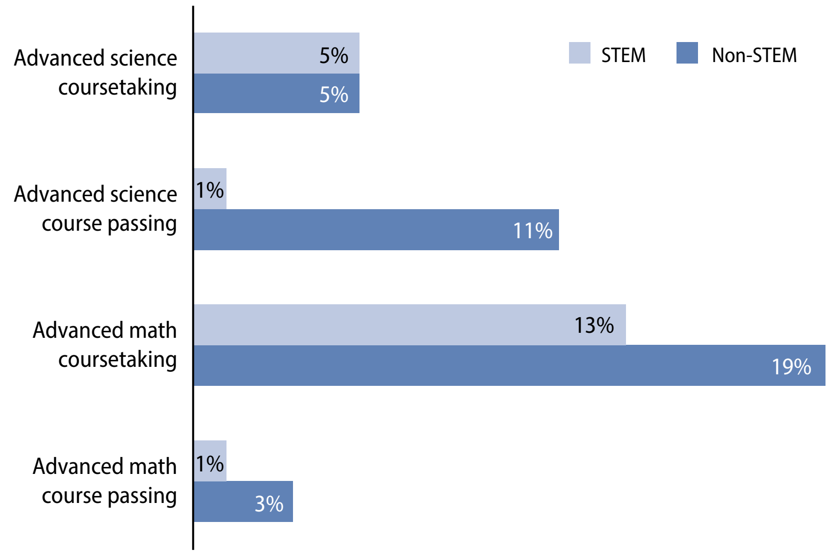
Free or Reduced-Price Lunch Eligibility Gap. First, we examine whether the coursetaking gap between free or reduced-price lunch students and their more affluent peers is smaller within the STEM schools than within the traditional schools. The gaps in advanced mathematics coursetaking and passing, and advanced science course passing, were smaller in STEM schools than in non-STEM schools (see Figure 1). For example, the gap between free or reduced-price lunch students and their more affluent peers in advanced mathematics coursetaking was 13 percentage points in STEM schools and 19 percentage points in non-STEM schools. For advanced science coursetaking, the gap was the same in both STEM and non-STEM schools (5 percentage points).

http://dx.doi.org/10.3768/rtipress.2016.rr.0025.1603

Among coursetakers, we found that the gaps between students eligible for free or reduced-price lunch and those who were not in passing science or mathematics were smaller in STEM schools than in non-STEM schools. The difference in pass rates between free or reduced-price lunch students and their peers in passing advanced science courses was 1 percentage point in STEM schools compared with 11 percentage points in non-STEM schools. The gap in passing advanced mathematics was 1 percentage point in STEM schools compared with 3 percentage points in non-STEM schools. These differences are statistically significant at the .01 level.

Racial Gap. In both STEM and non-STEM schools, students who were not members of an underrepresented minority group were more likely to take advanced science and mathematics classes than those in an underrepresented minority group. However, the difference in coursetaking was smaller in STEM schools than in non-STEM schools (Figure 2). In STEM schools, the racial gap for advanced science coursetaking was 2 percentage points, compared with 4 percentage points in non-STEM schools). The racial gap in the percentage of students who took advanced mathematics courses was four percentage points in STEM schools compared with 15 percentage points in non-STEM schools. These differences are statistically significant.

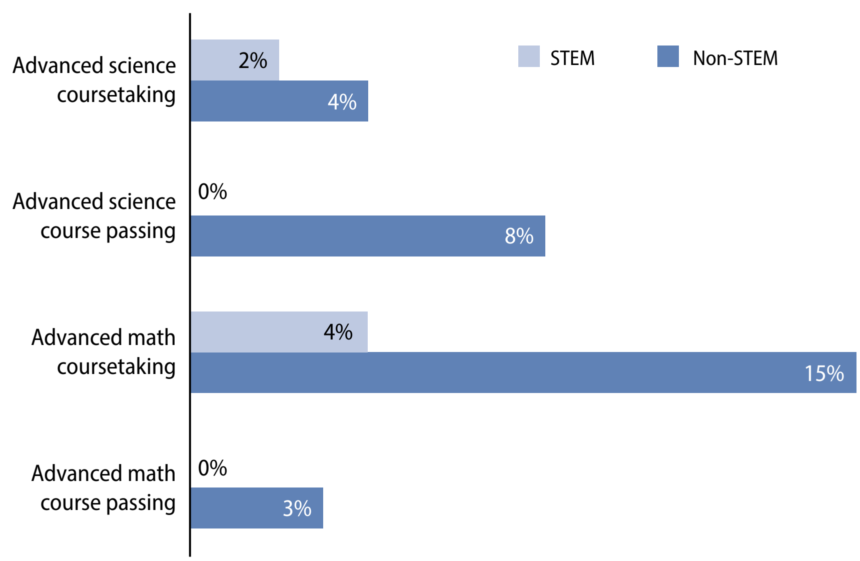
Figure 1. Percent difference in taking and passing advanced science and mathematics courses between students who were and were not eligible for free or reduced-price lunch, in STEM and non-STEM schools



Note: For the advanced science course passing and mathematics coursetaking and passing, the difference between the gap in the STEM schools and the gap in non-STEM schools is statistically significant at the .01 level.

Source: North Carolina Department of Public Instruction administrative data, 2011–2012.

Figure 2. Percent difference in taking and passing advanced science and mathematics courses between students who were and were not in the underrepresented minority group, in STEM and non-STEM schools



Note: For all of the coursetaking and course passing outcomes, the difference between the gap in STEM schools and the gap in non-STEM schools is statistically significant at the .01 level.

Source: North Carolina Department of Public Instruction administrative data, 2011–2012

Of students who took advanced classes, the racial gap in advanced science course passing was less than 1 percentage point in STEM schools compared with 8 percentage points in non-STEM schools. The racial gap in advanced mathematics course passing was smaller in STEM schools than in non-STEM schools. This gap was less than 1 percentage point in STEM schools compared with 3 percentage points in non-STEM schools.

Discussion

Past research has shown that high school STEM coursetaking influences the likelihood that students will progress in STEM after high school. This study explored how students in STEM schools progressed in terms of advanced science and mathematics coursetaking and passing, with a focus on students who are underrepresented in STEM. Even in STEM schools, advanced science and mathematics courses are not required for high school graduation, so taking and progressing in them may reflect greater motivation and interest in these subjects.

STEM schools in this study served a slightly higher percentage of students who are underrepresented in STEM in college and career: those who qualify for free or reduced-price lunch and those who are members of certain ethnic groups. Before entering high school, these students had lower end-of-grade mathematics and science test scores. Furthermore, under North Carolina's accountability system, a lower percentage of STEM schools had least 80 percent of students performing at grade level compared with the non-STEM schools. Students in STEM schools were less likely to take advanced mathematics classes than their peers in non-STEM schools. However, students in STEM schools were just as likely to take advanced science courses, and the students in STEM schools who took advanced science or mathematics classes were more likely to pass them.

This pattern persisted in almost all of the subgroups. Students who were eligible for free or reduced-price lunch and underrepresented minority students in STEM schools were more likely to both take and pass advanced science and mathematics classes than their peers in non-STEM schools.

For economically advantaged students and those who were not members of underrepresented minority groups, results were mixed. In some cases, we found no difference between students in STEM and traditional schools, whereas in other cases, students in traditional schools took or passed more courses. These schools are targeting disadvantaged students and may benefit them differently. If more of these schools are open, they should target populations of disadvantaged students.

The instruction in these STEM schools focuses on project-based learning, real world applications of knowledge, and making connections across subjects. These results suggest that such instruction may encourage students take these kinds of classes. When they have the supports for taking them, these students can pass.

Given that these students are more likely to take advanced science classes, it is surprising that fewer students in STEM schools would take advanced mathematics classes than their peers in traditional schools. Schools may focus on student success in required STEM courses and less on the advanced courses. If a STEM school's theme is geared more toward career and technical education, teachers may promote technical courses to a greater extent. Some of these schools have partnerships with 2- or 4-year colleges, which makes it easier for students to take college courses that may not be tracked in the state's high school data system. Future research should examine the paths by which students elect to take such courses.

Gaps in advanced science coursetaking and passing persist in STEM schools. In both traditional and STEM schools, more students typically enrolled in STEM take advanced mathematics and science courses. For example, in STEM schools, 18 percent of students who are eligible for free or reduced-price lunch take advanced mathematics compared to 31 percent of students in those schools who are more economically advantaged. Yet the difference between these groups of students in their coursetaking rates is greater in traditional schools than in STEM schools.

RTI Press Publication No. RR-0025-1603. Research Triangle Park, NC: RTI Press. http://dx.doi.org/10.3768/rtipress.2016.rr.0025.1603

These findings suggest that STEM schools are more equitable than the non-STEM schools. In almost all comparisons, gaps in advanced coursetaking and passing were smaller in the STEM schools than the non-STEM schools. This is despite the fact that NSNC STEM schools tend to serve students who might be less likely to pursue STEM classes in high school. Compared with neighboring non-STEM schools, the STEM schools served a higher percentage of students who were underrepresented minorities and who qualified for free or reduced-price lunch. Students in STEM schools had lower SAT scores than those in matched schools in the district or the neighboring district and had lower end-of-eighth-grade test scores, indicating that these schools are not targeting high-achieving STEM-gifted students. Thus, although many results are substantively small and some favor those in non-STEM schools, on the whole, the results are encouraging.

If STEM schools reduce gaps in taking and passing advanced mathematics and science classes, that does not necessarily mean that these schools have reduced gaps in student knowledge gains. Some advanced mathematics and science classes are more challenging than others. Students who take and pass the most challenging courses probably have more STEM knowledge than those who take less rigorous courses. Future work could examine whether some kinds of advanced mathematics and science classes contribute the most to STEM readiness in college. Even if students in different schools take the same course (e.g., precalculus), one class may be more rigorous than another, or one teacher may be more lenient than another. Comparing instruction in the same courses across schools would highlight effective teaching strategies.

These findings are based on a snapshot of one academic year. Future work should examine student progress over time. Additionally, we focused on STEM schools associated with a particular service provider, NCNS. Future research could explore approaches that other schools take in promoting STEM.

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Appendix. Classification of Advanced Science and Mathematics Courses

Table 1. Classification of advanced science courses

Course code	Course title
3029	Genetics
3030	Microbiology
3021	Biology II (2nd Year)
3024	IB Biology III
3051	Chemistry II (2nd Year)
3053	IB Chemistry III
3061	Physics II (2nd Year)
3062	IB Physics III
3063	AP Physics B
3064	AP Physics C
3080	Special Interest Science
3999	Community College Science

Note: Advanced science courses include chemistry II, physics II, advanced biology, and all Advanced Placement (AP)/International Baccalaureate (IB) science courses.

Table 2. Classification of advanced mathematics courses

Course code	Course title
Trigonometry, algebra III, probability/statistics	
2041	Trigonometry
2031	Analytical Geometry
2054	Integrated Mathematics IV
2071	IB Mathematical Studies 1
2081	IB Mathematical Methods 1
2025	Advanced Functions and Modeling
2074	IB Mathematical Methods 2
2063	Special Topics In Mathematics
2073	Fifth Year Mathematics
2078	Mathematics HL I IB
2065	Probability and Statistics
2066	AP Statistics
2499	Community College Mathematics
2498	Community College—4th Mathematics
Precalculus	
2070	Precalculus
2072	IB Mathematical Studies 2
2079	Mathematics HL II IB
Calculus	
2076	AP Calculus (AB)
2077	AP Calculus (BC)
2080	Mathematics HL III IB

Note: Advanced science courses include chemistry II, physics II, advanced biology, and all Advanced Placement (AP)/International Baccalaureate (IB) science courses.

http://dx.doi.org/10.3768/rtipress.2016.rr.0025.1603

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