

Beginning in the MIDDLE: Mathematics Pathways



Importance of the Mathematics Pathway

Key points in mathematics research:



Success with algebra is key.



Four years of high school math is essential.

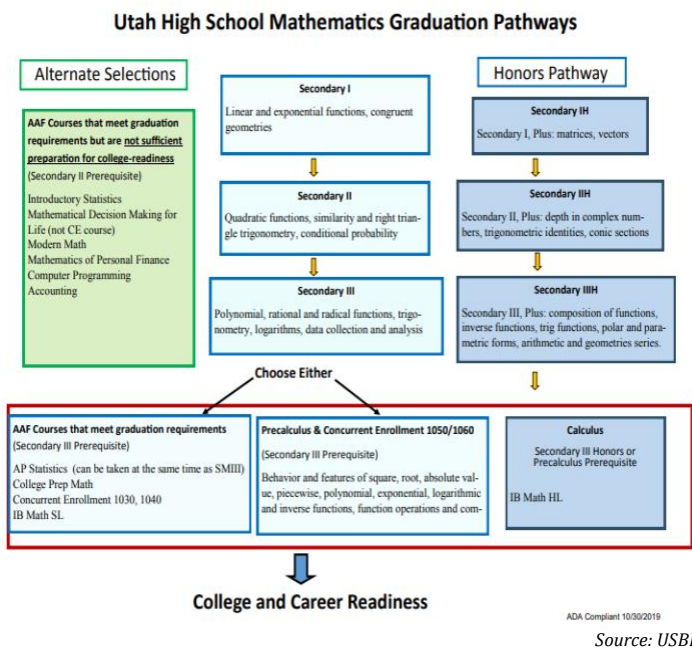
Research consistently demonstrates the lasting effects of mathematics achievement on a student's educational trajectory (Finkelstein et al., 2012). The pathway to mathematics success begins in elementary school and cumulatively builds through middle school math, which then leads to success and opportunities in high school and beyond (Oakes et al., 1992; Wang & Goldschmidt, 2003).

Much attention has been given to the importance of taking four years of high school math, including how doing so positions students for success when pursuing postsecondary education (Finkelstein et al., 2012). In Utah, for example, students are twice as likely to meet college math requirements when they successfully complete courses beyond the Secondary Math III requirement (Utah System of Higher Education, 2015). Additionally, taking higher levels of math in high school has been found to be strongly correlated with scoring higher on the American College Test (ACT), entering a four-year university, and completing a bachelor's degree (Darling, 2010; Walston & McCarroll, 2010; Zelkowski, 2008). Completion of rigorous high school math courses also increases the likelihood that students will earn higher salaries post-high school graduation even when factors like demographics, family, school characteristics, degree type, major, and occupation are accounted for (Levine & Zimmerman, 1995; Long et al., 2012; Rose & Betts, 2004).

Despite the evidence of the benefits of rigorous mathematics pathways, less attention is given to the time prior to secondary education. Yet, mathematics in middle school can be an important grounding for students as they progress to high school mathematics where credit will be earned towards a diploma. In a National Education Longitudinal Study, Stevenson and colleagues (1994) found that students who begin an accelerated course sequence in eighth grade, particularly participation in algebra, are more likely to stay on this trajectory until the end of high school. The trend to encourage all eighth graders to take algebra has highlighted the need for discussions of student readiness and preparation, particularly as very few students who repeat algebra after their first attempt achieve proficiency (Finkelstein et al., 2012).

For this analysis, we focus on Secondary Math I. In part, this focus was selected to determine if the depth of research, that illustrates how successful completion of algebra content lays the foundation for later coursework and creates a gateway to mathematics courses that can be completed prior to postsecondary school, was reflected in Utah (Finkelstein et al., 2012).

Figure 1 Utah High School Mathematics Pathways



Mathematics Pathways in Utah

In Utah, middle school students are required to take Grade 7 and Grade 8 mathematics courses. High school graduation requirements include a minimum of three credits in math. In a traditional math pathway, students must successfully complete Secondary Mathematics I, II, and III or higher for graduation. See Figure 1. Secondary Math I, which is typically taken in grade 8 or grade 9, includes algebra course content. Taking Secondary Math I earlier in one’s pre-college career path increases the opportunity for more advanced courses in high school (Stevenson et al., 1994). Utah categorizes mathematics courses into three categories:

Foundation, Advanced, or Applied. Foundation courses cover Secondary Math I, II, III and Pre-calculus. Advanced courses include Advanced Placement (AP) options such as Calculus, Statistics, College Prep Math, and courses within the International Baccalaureate program. Applied courses are for students that opt out of Secondary Math III and choose a third or fourth course with content such as accounting, computer programming, personal finance, or medical math. Students may replace Secondary Math III with a course from the Applied or Advanced approved course list with parent/guardian consent.¹

Utah Secondary Math I Participation

- Between 2015 and 2019, a majority (87%) of Utah students took Secondary Math I in ninth grade. See Figure 2.
- Students who take Secondary Math I in the 7th and 8th grades complete the course with higher GPAs than students who take it in the 9th, 10th, 11th, and 12th grades. See Figure 3.
- Seniors who take Secondary Math I earn higher mean GPAs than their 10th and 11th grade peers.
 - 38% of seniors in this study, however, were repeat takers. 55% did not complete the three required math courses.

Figure 2 Grade Students Take Secondary Math I

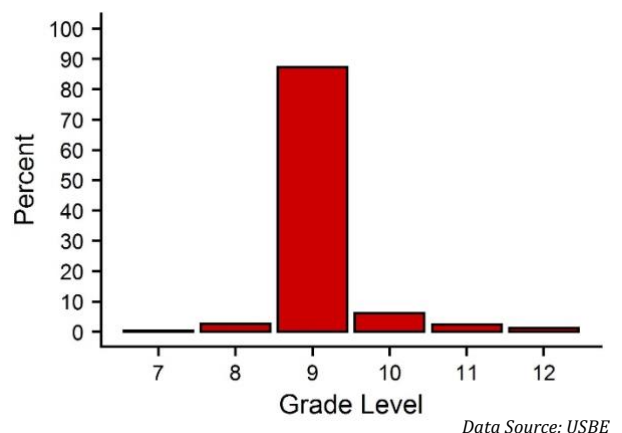
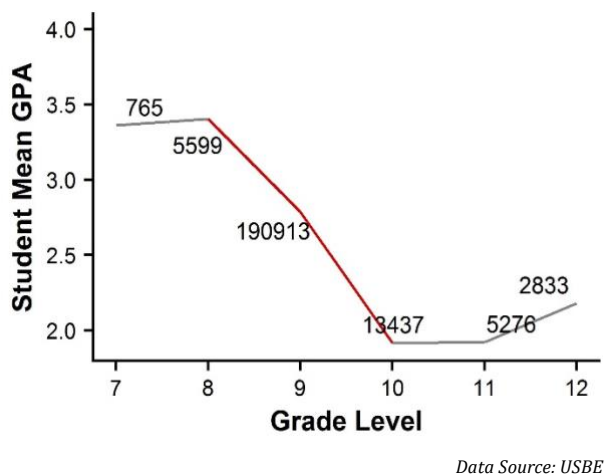


Figure 3 Secondary Math I Mean GPA by Grade Level



- Over 92% of students who take Secondary Math I in 7th, 8th, or 9th grade pass the course as compared to 77% of 10th and 11th graders and 83% of 12th graders, regardless of the number of attempts (i.e., first, second, third, or fourth attempt). See Figure 4.

Figure 4 Secondary Math 1 Percent Passing Across Grade Levels

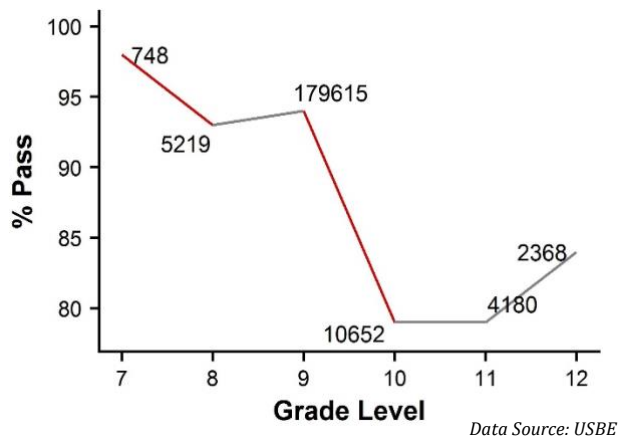
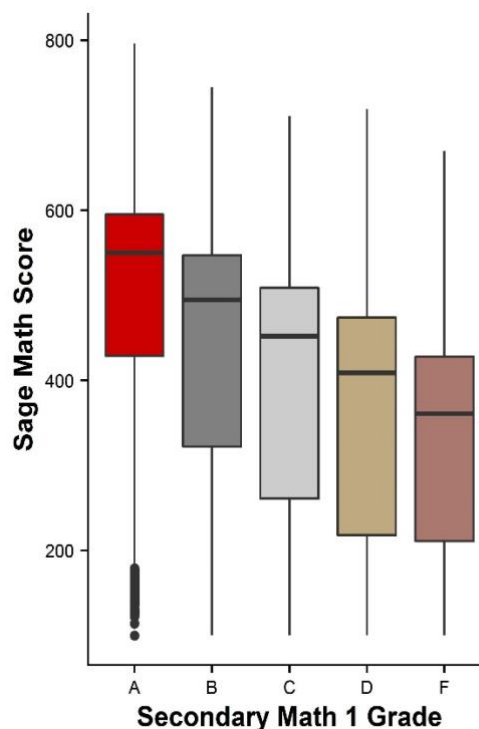


Figure 5 Relationship Between SAGE Score and Secondary Math I Grade from Same Year Test Was Taken



- Figure 5 illustrates the relationship between Secondary Math I GPA and SAGE scaled score from the same year. The line within each box represents the median SAGE score associated with each letter grade (A-F) in Secondary Math I. Additionally, the lines extending from the boxes represent the range of SAGE scores earned by students with each Secondary Math I grade.
- As Figure 5 shows, there is a strong relationship between Secondary Math I grade and SAGE score. Students who earn higher grades in the course also score higher on the standardized test.

Table 1 Percent Passing Secondary Math I Across Attempts

Grade Level	1 st Attempt	2 nd Attempt	3 rd Attempt	4 th Attempt
7th	91.3%	8.7%	--	--
8th	93.6%	6.1%	0.3%	--
9th	98.2%	1.7%	0.1%	--
10th	72.4%	25.4%	2.2%	--
11th	69.3%	23.3%	6.4%	0.9%
12th	79.8%	16.6%	3.2%	0.4%

Data Source: USBE

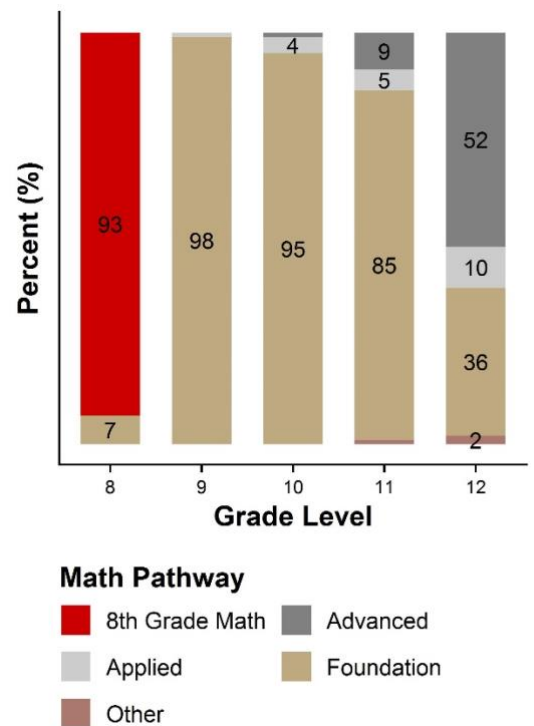
- In Utah, a majority of students are successful at passing Secondary Math I on their first attempt. Ninth grade, which is when a majority of students take the course for the first time, had the highest percent (98.2%) passing on the first attempt.
- A much lower percent of students pass Secondary Math I on their 3rd and 4th attempts. See Table 1.

Exploring Utah Math Course Participation

At the national level, it is estimated that 24% of 8th grade students take Algebra 1 and about 19% of high school seniors enroll in calculus or higher, which is defined as calculus, AP/IB calculus, and other AP/IB mathematics (National Science Board, 2018; U.S. Department of Education, 2018).

- In Utah, 7% of 8th grade students take Secondary Math I, which is the equivalent of Algebra I. See Figure 6.
- Between the 9th and 11th grades, most Utah students (between 85% and 98%) enrolled in mathematics take Foundation math courses, that is, Secondary Math I, II, III, or Pre-calculus.
- In the 12th grade, a majority (52%) of Utah students enrolled in mathematics take an Advanced math course.
- 18% of 12th grade students enrolled in mathematics in Utah take calculus, AP/IB calculus, or other AP/IB mathematics. See Table 2.

Figure 6 Math Pathways Across Grade Level



Data Source: USBE

Table 2 Advanced Math Courses

Math courses below calculus	82.5%
Calculus, AP/IB calculus, and other AP/IB mathematics	17.5%

Data Source: USBE

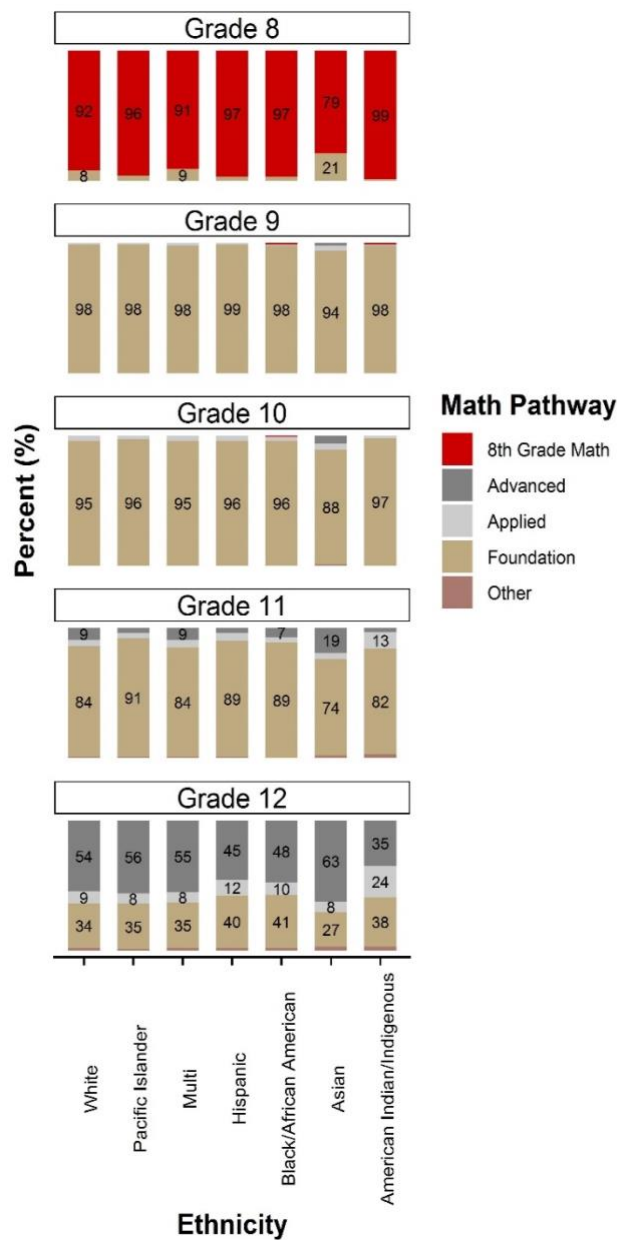
Demographics of Math Course Participants

Ethnicity

Nationally, participation in advanced math courses is divided along clear racial/ethnic lines, with Asian and White students being more represented among advanced math course takers than students from other racial/ethnic groups (Edge, 2009; National Science Board, 2018; U.S. Department of Education, 2018; Walston & McCarroll, 2010; Wang & Goldschmidt, 2003). See Figure 7 for mathematics participation by grade level, course, and ethnicity in Utah.

- In Utah, the majority of 8th grade students, irrespective of racial or ethnic background, enroll in Grade 8 mathematics. In the 9th and 10th grades, most Utah students, regardless of race or ethnicity, take Foundation math courses.
- By 11th grade, mathematics course participation in Utah begins to diverge significantly by race. These variations include a high of 19% of Asian students taking Advanced math courses in the 11th grade, as compared to a low of 3% to 4% of students who are Hispanic, Pacific Islander, or American Indian/Indigenous.
- In the 12th grade, significant variation in participation in Advanced math courses also exists. Students who are American Indian/Indigenous are the most under-represented among students in Advanced math courses in 12th grade. These students have the highest participation rate in Applied math courses in 12th grade.

Figure 7 Math Pathways by Ethnicity



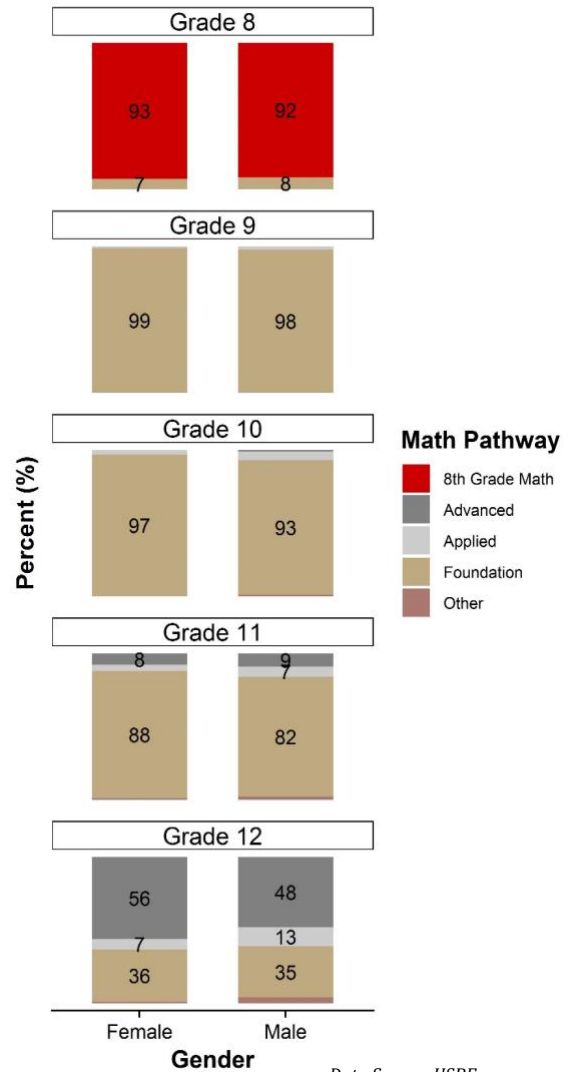
Data Source: USBE

Gender

Current research findings suggest that a slightly higher percentage of female students (25%) than male students (22%) take Algebra 1 in the 8th grade (U.S. Department of Education, 2018). Additionally, a comparative percentage of female and male students enroll in advanced math courses in high school (National Science Board, 2018; Riegle-Crumb, 2006). See Figure 8 for information about mathematics participation in Utah by gender.

- In Utah, however, a similar percent of male students (8%) and female students (7%) enroll in Secondary I Math in the 8th grade.
- Differences, however, seem to emerge in the math course-taking patterns of female and male high school students in Utah.
- Between the 10th and 12th grades, a higher percentage of male students than female students enroll in Applied math courses.
- In the 12th grade, female students in Utah notably outpace their male peers in taking Advanced math courses—56% as compared to 48%.

Figure 8 Math Pathways by Gender



Data Source: USBE

Socioeconomic Status

Studies show that school-aged students from households with greater economic resources tend to be more represented in higher level math courses than their peers from households with fewer economic resources (Bozick and Ingels, 2008; National Science Board, 2018; Walston & McCarroll, 2010). This finding also holds true for middle school and high school students in Utah, as illustrated in Figure 9.

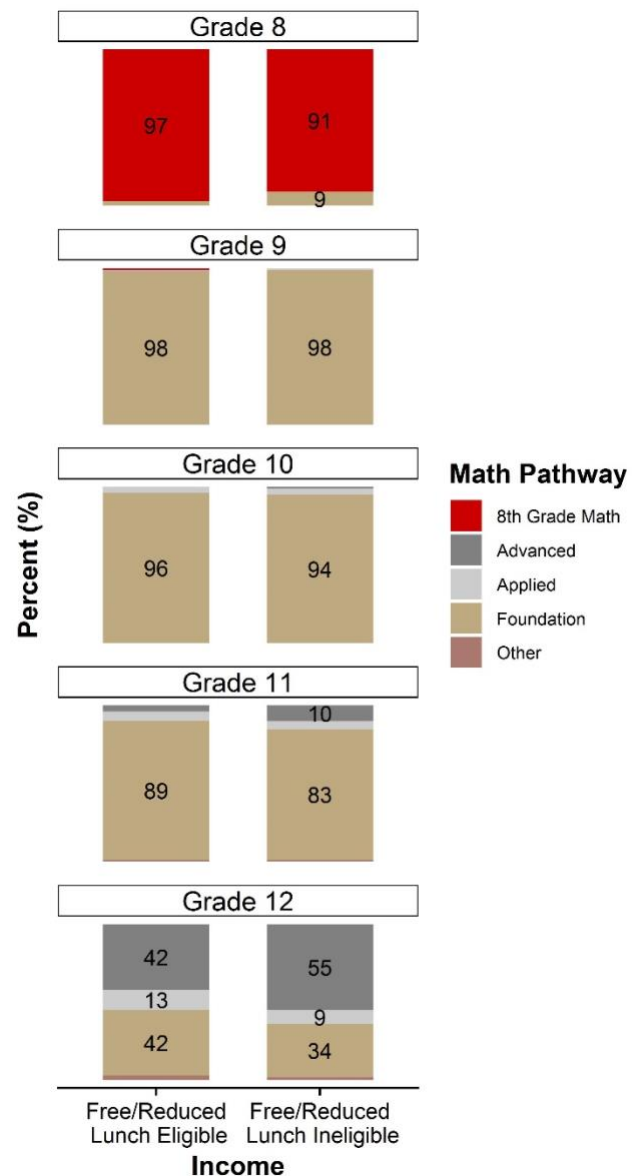
- Students eligible for Free and Reduced Lunch are less represented in Foundation courses in the 8th grade.
- Students eligible for Free and Reduced Lunch are less represented in Advanced Courses in the 11th and 12th grades.

Number of Math Courses Completed by High School Graduates

As research suggests, continuous enrollment in mathematics, or taking four years of math, in high school is a stronger predictor of bachelor's degree attainment than the completion of particular mathematics courses (Finkelstein et al., 2012; Zelkowski, 2010). See Figure 10 for information on mathematics participation by graduation year.

- In Utah, nearly 60% of high school students take four or more mathematics courses over the course of their high school careers.
- 33 and 36% of Utah high school students in the 2018 and 2019 graduating class, respectively, took three mathematics courses, while approximately four percent took fewer than three mathematics courses.

Figure 9 Math Pathways by Socioeconomic Status

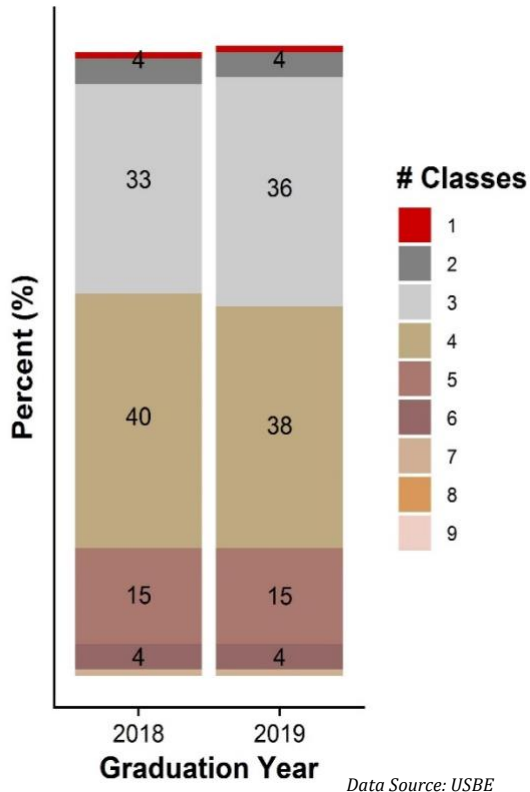


Data Source: USBE

Summary

The initiation of the *Algebra for All* movement in the 1990s brought increased attention to both the need and the timing of algebra course participation. This movement also emphasized the subsequent sequence and availability of math courses. Evidence continues to demonstrate the impact of middle school math participation

Figure 10 Number of Math Classes by Graduation Year



and achievement on secondary and post-secondary math access and participation. To begin to address the role of middle school in establishing a stronger foundation for STEM pursuits, this brief explores participation and persistence in mathematics between the 8th and 12th grades in Utah.

Given the emphasis of the *Algebra for All* movement, previous studies have investigated when students take this course, how often students have to take algebra in order to be successful, and the impact of this course on the student's mathematics trajectory. In Utah, almost 90% of students take Secondary Math I in 9th grade, although a small percent of 10th, 11th, and 12th grade students also take this course. While seniors have a higher GPA in the course when they take it compared to 10th and 11th graders, it is important to note that these students will also not be finishing their required three math courses for graduation due to the need for three credits in mathematics. Given the decline in GPA when students take Secondary Math I later in their schooling career and the lower likelihood that students who take Secondary Math 1

after 9th grade have to complete three or more mathematics courses, this study opens the door to ask further questions about how GPA predicts mathematics participation and course taking trajectories. Further research is needed to understand the types of support students who do not take and pass Secondary Math I by 9th grade receive and how these supports may help accelerate their achievement and increase access to math pathways to ensure successful completion of the graduation requirements and to advanced mathematics pathways.

Without question, there are a number of factors that influence whether or not students choose to pursue additional or advanced mathematics courses. Given this study, further inquiry is needed to explore how teacher knowledge and pedagogical skills and factors such as student subject-matter performance, interest, engagement, and even course availability may influence student choices and access to mathematics pathways. Research of this nature could further inform the preparation and professional learning needed for educators as well as provide guidance and supplementary support offered to students to enhance both enrollment and achievement in mathematics pathways.

Finally, as discussed in this brief, nearly 60% of Utah students take four or more mathematics courses by their expected graduation year. Our upcoming studies will explore a) the predictive value of grades and timing of Secondary Math I on future course participation and success, b) the impact of math course participation on the STEM trajectory in post-secondary education, and c) the relationship between the total number of mathematics courses taken and the types of postsecondary institutions in which students later enroll.

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Appendix

Methods

This study uses records from school years 2015-2019 and was completed in fulfillment of the Utah Data Alliance grant for which the UEPC was a research partner. When a single year was reported, data from the most recent school year, 2019, was used. Given the focus of this brief on math course-taking, only student course data (or core codes) corresponding to math courses were included in the analysis. Supplemental math courses, however, were excluded from the analysis. To facilitate a more interpretable understanding of math course participation, math core codes were grouped using categories pre-defined by the USBE—that is, Advanced, Applied, and Foundation. These groupings were used in generating the descriptive statistics (counts and percentages) presented in the brief and represented in tables and figures. This brief reports data for students in grades 8-12. Course numeric grades were converted to letter grades in line with the following scale used by the College Board: 3.7+ = A, 2.7 - 3.6 = B, 1.7 - 2.6 = C, >0 – 1.6 = D, 0 = F.ⁱⁱ SAGE scores were reported for students taking the SAGE test associated with the Secondary Math I course. When multiple student records for a single student in a school year were reported, the record with the greatest attendance days was selected for the analysis.

Data Share Agreement

This research uses data made available through a Data Share Agreement (DSA) between the Utah State Board of Education and the UEPC, and the UEPC adheres to the USBE Data Privacy Guidelines for data analysis and reporting. The views expressed are those of the authors and not necessarily the USBE nor endorsed by the USBE.

Suggested Citation

McCormick, K., Rorrer, A. K., Onuma, F. J., Moore, B., & Pecsok, M. (2020). *Beginning in the Middle: Mathematics Pathways*. Utah Education Policy Center: Salt Lake City, UT.

Endnotes

ⁱ For more information about math course requirements in Utah, visit:

<https://www.schools.utah.gov/curr/graduationrequirements?mid=1014&tid=2>

ⁱⁱ For more information on the College Board's grade conversion scale, visit: <https://pages.collegeboard.org/how-to-convert-gpa-4.0-scale>