POLICY BRIEF:

Mathematics Pathways in Texas

Texas OnCourse Research Network

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KEY FINDINGS

Most students follow regular mathematics course pathways through middle and high school, with two types of distinguishing branches:

Students can get ahead early on by beginning Algebra I before high school.

Students can fall behind in later years by repeating courses or taking a review course (Mathematical Models with Application), and there are no "catch-up" pathways

Branches of both types contribute to economic inequality, but disparities are most pronounced relatively rare early branches such as beginning Algebra in 7th grade or delaying Algebra to 10th grade.

Both branch types are predictive of post-secondary enrollment after high school after controlling for mathematic achievement and other student characteristics.

Introduction

Mathematics success in high school is critically important for individual students and for the state. It provides skills and post-secondary opportunities that support a robust workforce. A recent report by the Greater Texas Foundation[1] found that completing higher mathematics predicted post-secondary benefits, while noting persistent social background disparities in completion. These patterns highlight the need to promote more advanced, and more equitable, mathematics coursework.

Designing and evaluating policies to improve ultimate mathematics outcomes requires first understanding the ways that students arrive at their destination. The sequential design of most mathematics courses shape how students can advance during school, leading to specific pathways through mathematics curricula. The shape of these pathways create critical moments of opportunity and lasting consequences. As the state shifts from a "one size fits all" model of high school curricula, it is important to isolate critical junctures students will face as they proceed through school.

This brief maps students' progress through mathematics courses in the state, highlighting particularly consequential moments of transition. It asks:

1. Where are the key branching points as students progress through coursework in mathematics?
2. At what branching points are social background disparities most pronounced?
3. How are divergent course branches related to the transition to post-secondary school?

Data

This study uses data from the Education Research Center (ERC) at the University of Texas at Austin. Yearly data from the Texas Education Agency tracks students' course enrollments. These longitudinal records

[1] Wiseman, Hamrock, Bailie, and Gourgey. 2015. Pathways of Promise: Statewide Mathematics Analysis. Greater Texas Foundation Policy Brief

are also linked to post-secondary enrollment records from the Texas Higher Education Coordinating Board and, for students enrolling outside the state, to information from the National Student Clearinghouse. Thus, the data provide a picture of students' mathematics course-taking pathways throughout middle and high school, how these pathways differ for different student groups, and consequences through transitions to college.

This report focuses on a single recent cohort of student who were 8th grade students in 2010-2011. These students were expected to graduate from high school in 2015 and thus are the most recent cohort that can currently be tracked into post-secondary records. During this time, most students completed the Recommended High School Program, which required four credits in Mathematics.

Students typically progress from grade level mathematics in elementary and middle school to Algebra I, Geometry, Algebra II, and Pre-calculus. Mathematical Models with Application is an optional additional course prior to Algebra II. Calculus AB, Calculus BC, and Statistics are Advanced Placement options at the end of students' high school careers. Considered state mathematics courses are presented in Table I. This study excludes other mathematics courses, such as International Baccalaureate (which provides a specialized progression) and Independent Study (a category which covers disparate courses).

Key findings

The shape of mathematics course-taking sequences

Figure 1 presents mathematics pathways for all students in the state. Each line segment represents a specific transition from one course in one year to another in the next, with the width proportional to the number of students making that transition. This network shows how students proceed through different mathematics pathways, and how the cohort branches out from grade level mathematics in grade 6 to a variety of ultimate destinations by the end of high school.

The thick, parallel upward-sloping lines in this figure show that most students follow the traditional sequence of mathematics courses from Algebra I to Geometry to Algebra II to Pre-calculus. Two features of these paths are notable. First, deviations from this progression are rare. Where different pathways do exist, they tend to result in slower progress, such as repeating a course in the following year. Similarly, Mathematical Models with Application is often taken by students who struggled in Algebra I or Geometry, yet taking this course delays advancing to Algebra II. There are few substantial pathways from each course before the end of high school, with the exception of students who fall behind by repeating a course. Second, although students' progress follows the same sequence, it occurs at different times. A small number of students begin Algebra in 7th grade, while sizeable numbers begin Algebra in 8th and 9th grade.

Given the regularity of mathematics sequences and impossibility of accelerated progress, when students start Algebra I has lasting consequences. For instance, the small pathway through Algebra I in grade 7 leads invariably to advanced mathematics by the end of high school. "Fall-back" branches, including course repetition, are also notable.

Given this network of opportunities, we can define a branching point as a course and grade in which students' next mathematics course is not prescribed. Table 2 lists notable branches representing either initial acceleration (middle school Algebra) or later setbacks (such as repeating a course).

Course pathway branches and inequality

Course pathways are systematically related to students' background. More advantaged students tend to be more likely to experience initial acceleration and avoid later setbacks. We can see this graphically by coloring transition paths according to the proportion of those students who are economically disadvantaged (Figure 2). Economically disadvantaged students are over-represented in lower pathways: grade level mathematics in middle school, course repetition, and the Mathematical Models course (which delays Algebra II).

Can these differences be explained by differences between these student groups, such as state-assessed prior mathematics achievement? The answer is most cases is no. After controlling for student characteristics (including demographic characteristics, academic designations, school mobility, and prior mathematics achievement on state standardized tests), economic disadvantage is a significant predictor of most transitions. Poor students are particularly unlikely to begin Algebra in grade 7 (odds are half) and are especially likely to end up in Algebra I in 10th grade, either by enrolling in a grade level course in grade 9 (odds triple) or by repeating Algebra I in grade 10 (odds double). In addition, at the large branching after 7th grade, poor students' odds of Algebra I enrollment in eighth grade is 20% lower than for non-poor students.[2]

Course pathway branches and the post-secondary transition

Students taking higher pathways are more likely to enroll in post-secondary institutions in the fall following high school graduation. As Figure 3 demonstrates, more than half of students in the initial accelerated pathways ultimately enroll in college, compared to a third or fewer from lower pathways.

These differences hold controlling for student characteristics. With the exception of Algebra I enrollment in grade 7, higher branches predict greater enrollment. Downward mathematics pathways in high school are associated with very low odds of post-secondary enrollment. For instance, students who repeat Algebra I in 10th grade have half the odds of college-going compared to students who progress to Geometry.

It is important to note that these differences do not necessarily reflect the effects of course pathways per se, even though estimates control for initial mathematics achievement and other covariates. However, they are diagnostic of critical moments in students' development.

Conclusions

By mapping students' mathematics course pathways, this study details particular branching points that lead to different subsequent opportunities and ultimate outcomes. Although most students progress through a regular sequence of courses, there are branching points—especially in middle and early high school—where some get ahead and others fall behind. Since there are few "catch-up" opportunities, these branches shape future options and even early path differences predict outcomes beyond high school. Finally, points where course pathways diverge tend to exacerbate economic inequalities, as disadvantaged students are over-represented in lower pathways.

These findings have implications for counselors, teachers, and policymakers. First, possible pathways highlight the importance of early mathematics choices. It is essential to ensure that students' and counselors understand the lasting implications of early decisions, and these early decisions are likely to become more formative as new graduation standards encourage greater individualized choice in course-taking. Similarly, early mathematics preparation is a key foundation for taking and succeeding in high-return mathematics pathways. Any policies that target mathematics completion in high school also need to address elementary and middle school instruction. Finally, it is troubling that among students with similar initial mathematics achievement economically disadvantaged students are less likely to take more beneficial pathways. These patterns exacerbate inequality in the state and represent lost opportunities for human capital development in the state. The disparities documented in this study do not identify specific remedies, but they suggest the need for providing great early support and information to students with limited resources as they make formative curricular choices.

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[2] One exception to this pattern is that among students in pre-calculus in 11th grade, Poor students are less likely to transition to Statistics in place of Calculus. Among this selective group on relatively high-achieving students, economic background predicts higher senior enrollment.

Table 1. Mathematics Courses

Course	Modal Grade	Grade with at least 1% enrolled
Grade Level	6	6-8
Algebra I	9	7-10
Geometry	10	8-12
Mathematical Models	11	9-12
Algebra II	11	9-12
Pre-calculus	12	10-12
AP Statistics	12	11-12
AP Calculus AB	12	11-12
AP Calculus BC	12	12
Other	12	10-12

Table 2. Differences in odds of course branches for persistently economically disadvantaged students compared to non-disadvantaged, controlling for student characteristics

Original Grade	Original Course	Destination Course (% of original)	Comparison Course (% of original)		Likelihood for persistent economically disadvantaged students	
						Odds Ratio
Initial Acceleration Branches						
7	Grade	Alg I (1%)	Grade (99%)		Lower	0.53
8	Grade	Alg I (28%)	Grade (72%)		Lower	0.79
"Fallback" Branches						
9	Grade	Grade (1%)	Alg I (95%)		Higher	3.05
9	Alg I	Alg I (6%)	Geo (92%)		Higher	1.26
10	Alg I	Alg I (3%)	Geo (85%)		Higher	2.09
11	Geo	Math Models (13%)	Alg II (73%)		Not significant	
11	Geo	Geo (5%)	Alg II (73%)		Higher	1.87
12	Alg II	Alg II (2%)	Pre-calc (77%)		Higher	1.64
12	Pre-calc	Stats (10%)	Calc AB (53%)		Lower	0.49

Notes: Persistent economic disadvantage is economic disadvantage in each year from grades K-8. Results (not shown) are similar for "Transitory Disadvantage" student who experience some disadvantage during that time period. Each estimates is from a separate models comparing the likelihood of taking the focal destination course to the comparison one among students enrolled in the original course. Models control for school mobility, gender, race/ethnicity, Limited English Proficiency, Special Education status, gifted/talented designation, and standardized TAKS mathematics score in grade 6. All presented values statistically significant with a p value less than 0.01.

Table 3. Differences in odds of post-secondary enrollment in the fall following high school graduation controlling for student characteristics

Original Grade	Original Course	Destination Course (% of original)	Comparison Course (% of original)		Likelihood of Post-secondary Enrollment	
						Odds Ratio
Initial Acceleration Branches						
7	Grade	Alg I (1%)	Grade (99%)		Not Significant	
8	Grade	Alg I (28%)	Grade (72%)		Higher	1.88
“Fallback” Branches						
9	Grade	Grade (1%)	Alg I (95%)		Lower	0.03
9	Alg I	Alg I (6%)	Geo (92%)		Lower	0.49
10	Alg I	Alg I (3%)	Geo (85%)		Lower	0.19
11	Geo	Math Models (13%)	Alg II (73%)		Lower	0.46
11	Geo	Geo (5%)	Alg II (73%)		Lower	0.17
12	Alg II	Alg II (2%)	Pre-calc (77%)		Lower	0.25
12	Pre-calc	Stats (10%)	Calc AB (53%)		Lower	0.81

Notes: Post-secondary enrollment refers to October 15 of the year of high school graduation. Each estimate is from a separate models comparing the likelihood of enrollment for students taking the focal destination course compared to those in the comparison path among students enrolled in the original course. Models control for school mobility, gender, race/ethnicity, Limited English Proficiency, Special Education status, gifted/talented designation, and standardized TAKS mathematics score in grade 6. All presented values statistically significant with a p value less than 0.01.

Figure 1. Pathways through Mathematics in Texas

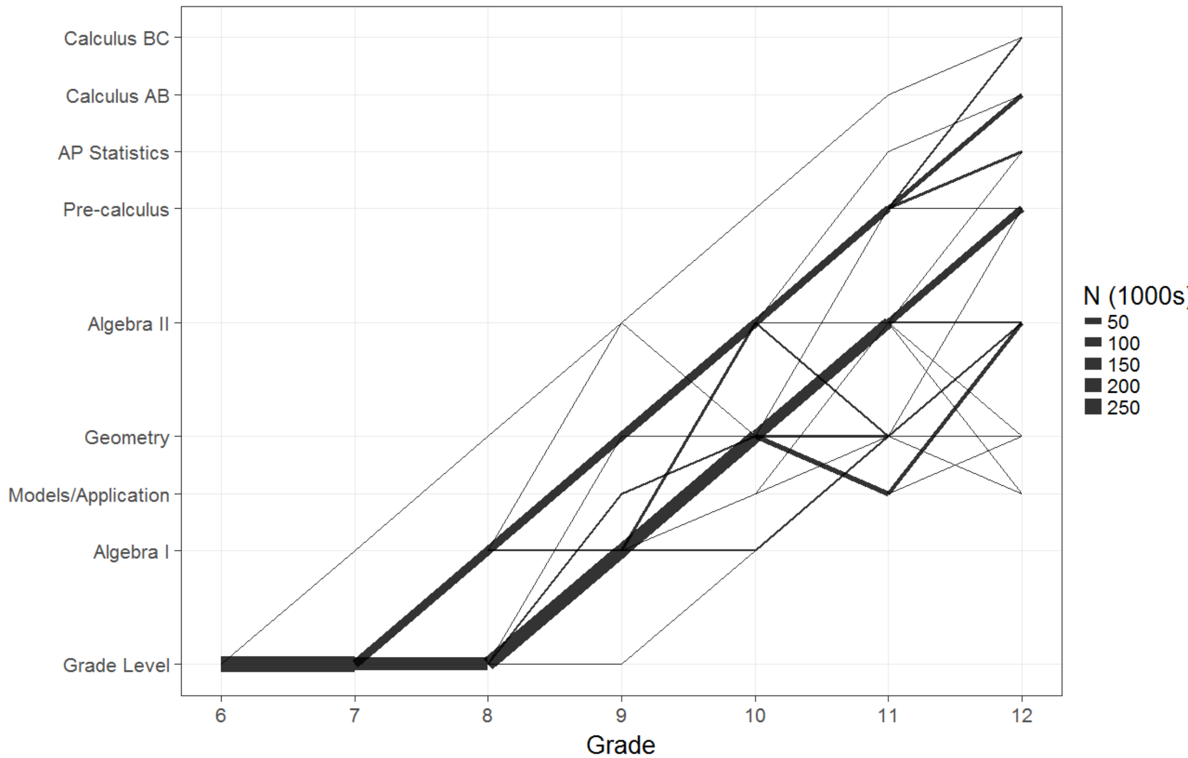


Figure 2. Course pathways and economic disadvantage

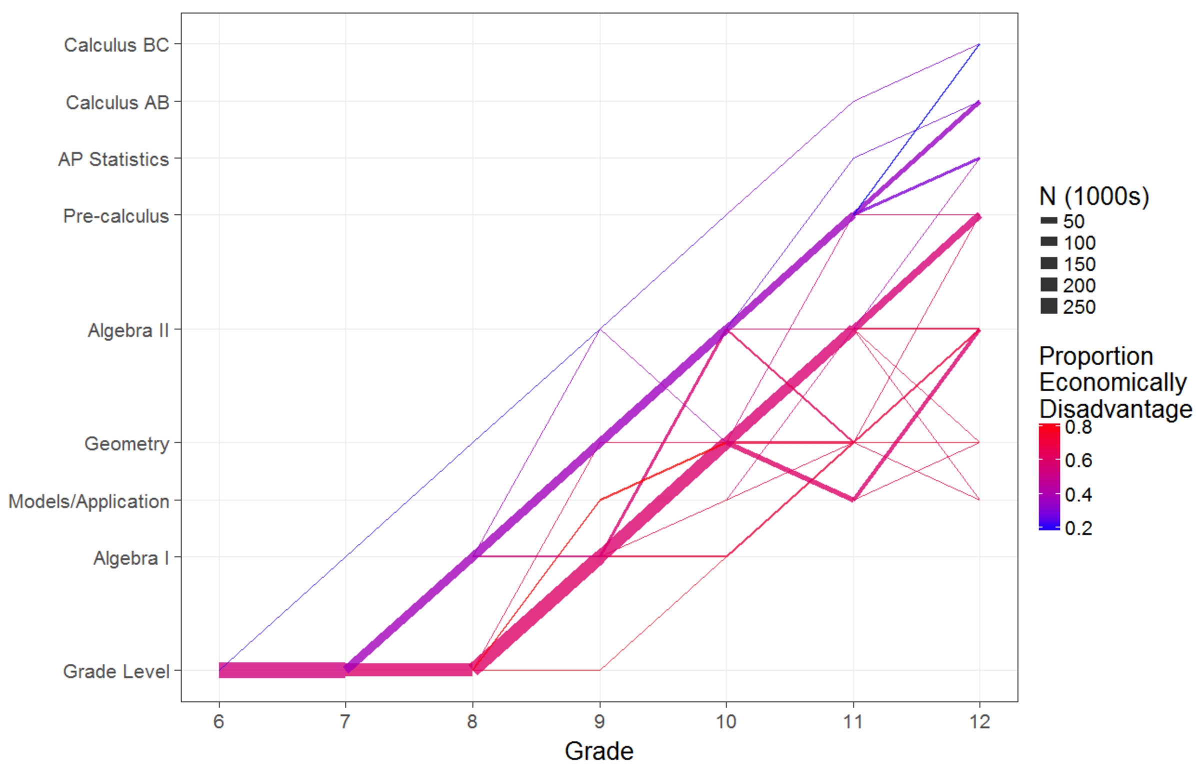
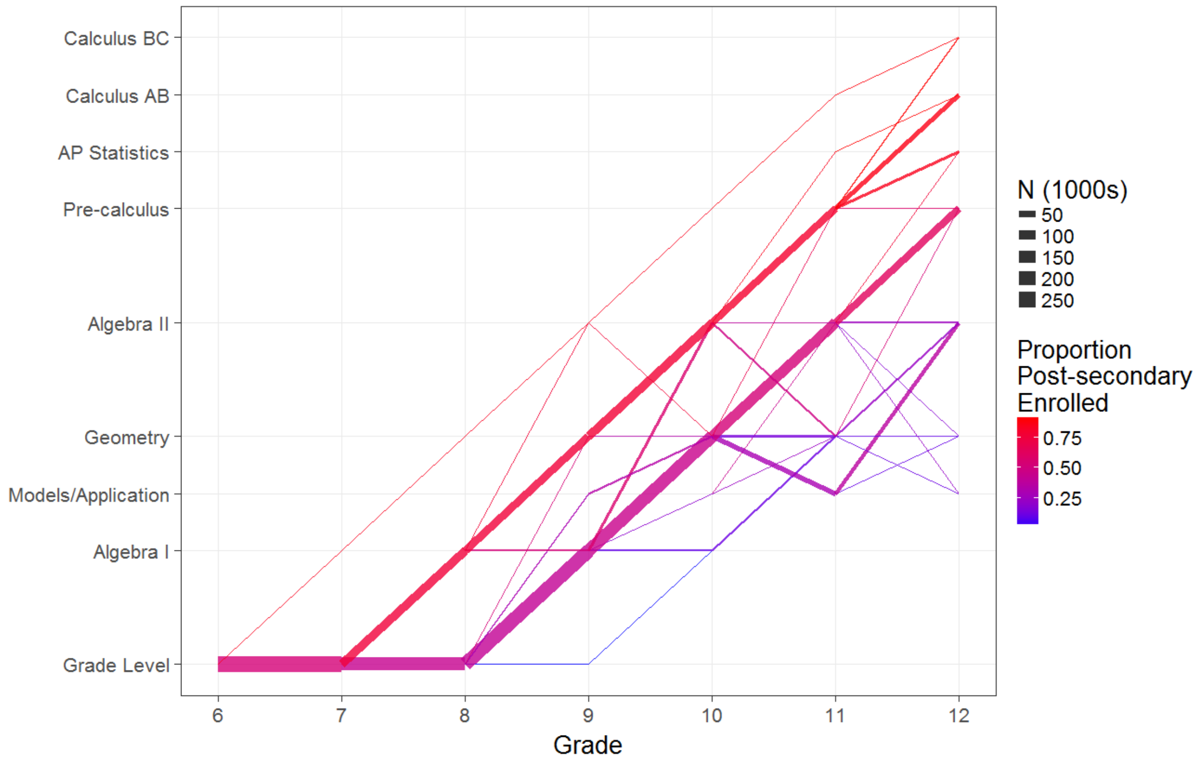


Figure 3. Post-secondary enrollment by pathway



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