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Pathways of Promise: Statewide Mathematics Analysis

A Study of Highest Level Math Mastered in High School and Education Outcomes
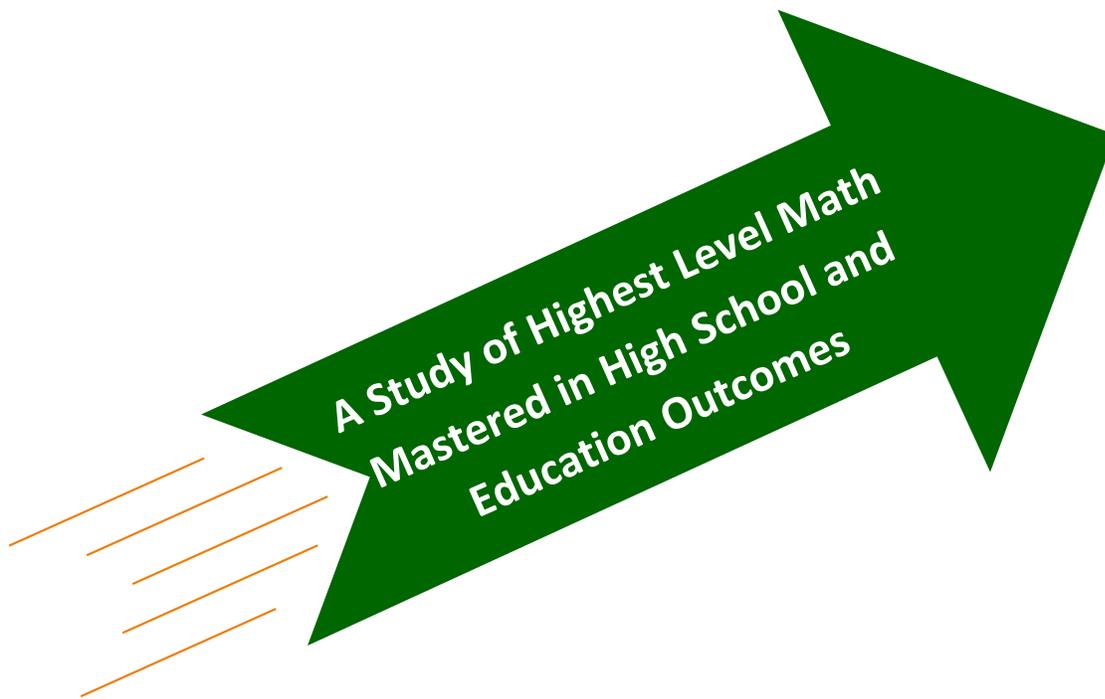
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About E3 Alliance

E3 Alliance is a regional, data-driven education collaborative based in Austin, Texas. Serving the Central Texas community, we partner with districts, higher education, and industry to build the strongest educational pipeline in the country to drive regional economic prosperity. Founded in 2006, E3 Alliance acts as a catalyst for change, working to break-down barriers and build better alignment across the education continuum. Our name tells our story: *Education Equals Economics*. We believe that only through greater education achievement for our current and future generations of children can Central Texas realize economic prosperity and a high quality of life for our community. Such education achievement requires systemic change from cradle to career, and that is our commitment to our community. www.e3alliance.org

Executive Summary

E3 Alliance facilitates **Pathways of Promise** (PoP), a research and implementation initiative in Central Texas designed to *identify and scale strong college and career pathways for high school students that lead to successful transitions to and completion of a postsecondary credential*. To develop the optimal career pathways calibrated to state and regional economies as directed by Texas Legislative House Bill 5, E3 conducted a *statewide* research study analyzing the relationship between the highest level of mathematics mastered by high school students and subsequent education outcomes, including: high school graduation, college and career readiness, college enrollment, 2-year to 4-year transfer, college completion, and college completion with a Science, Technology, Engineering, and Mathematics (STEM) degree.

This brief includes a short description of the research questions and methodology and the leading findings related to who takes and "masters" different levels of math and their education outcomes beyond high school. In this study, "mastery" refers to students who pass both semesters (as opposed to receive a cumulative passing grade over two semesters). The key findings from the study based on longitudinal analyses of both the 2003-04 and 2008-09 first time 9th grade cohorts are:

Distribution of Math Mastery for 2008-09 Texas first time 9th graders enrolled in High School for 4 years:

1. Vastly more students mastered Pre-Calculus (instead of stopping at Algebra II) under the legislative requirement known as "4x4" compared to before this requirement. The "4x4" mandated that high school students default to taking four credits (four years) of each of the core subject areas: English Language Arts, Mathematics, Science, and Social Studies.
2. Low income student mastery of Pre-Calculus doubled (to 29%) from the 2004 9th grade cohort to the 2009 9th grade cohort.
3. Smaller shares of students in rural districts and less populated regions mastered Pre-Calculus or an Advanced Placement (AP)[1] course as their highest math compared to their urban and suburban peers.
4. 20% of non-low income students mastered an AP math class (Statistics, Calculus AB, or Calculus BC) compared to only 7% of their low income peers.
5. 75% of Asian students mastered Pre-Calculus or higher compared to 36% of Black, 39% of Hispanic, and 52% of White students respectively.
6. A higher proportion of males (26%) mastered less than Algebra II as their highest level of math compared to 17% of females. A smaller share of males mastered Pre-Calculus (29%) than females (35%), but the distribution evens out for AP math courses (12% and 13% respectively).

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[1] Advanced Placement is a program provided by the College Board that offers "college-level" courses in the United States and Canada. Students take a standard exam at the end of the course and colleges may opt to offer placement or credit for the course based on those results.

Outcomes Associated with Highest Level Math Mastered in High School:

1. Previous research by E3 Alliance revealed that 43% of non-low income 2012-13 Central Texas 8th graders completed Algebra I by the end of their 8th grade year versus only 17% of their low income peers.[1]
2. 43% of 2009 9th graders with Algebra II as their highest level math were college and career ready compared to 70% for Pre-Calculus, 88% for AP Statistics, 92% and 95% for Calculus AB and BC, respectively.
3. Students who mastered Pre-Calculus while in high school were twice as likely to enroll in higher education as their peers whose highest level of math was Algebra II.
4. 36% of 2009 9th graders (enrolled in high school all 4 years) who mastered Algebra II as their highest math persisted into their second year of higher education, compared to 58% for Pre-Calculus, 68% for AP Statistics, 74% and 72% for Calculus AB and BC, respectively.[2]
5. Income gaps in persistence rates decrease as highest level math mastered increases, though these gaps do not entirely close. In contrast, whether a student enrolled full time ($\geq$ 12 credits) versus part time (< 12 credits) showed an even stronger and more consistent relationship with 2nd year persistence rates. Full time college students persisted at higher rates than part time students regardless of the highest level of math mastered in high school, with an average persistence gap of 30 percentage points.
6. Students who mastered at least Pre-Calculus were more likely to transfer from a 2- to 4- year college. Full-time as compared to part-time status also had a strong influence on transfer rates.
7. Of the 2004 9th grade cohort who enrolled in higher education, 47% completed within 6 years of initially enrolling.
   a. 36% with Algebra II as highest math mastered completed a post-secondary credential.
   b. Large gaps in completion exist by income and by ethnicity even at highest level of math mastery.
   c. Students with Pre-Calculus as their highest level of math were nearly twice as likely to complete their degree as their peers whose highest level was Algebra II.
   d. Students with Calculus were more than three times as likely to complete as their Algebra II peers and were 80% more likely to complete than their Pre-Calculus peers.
8. Almost 1 in 3 students who completed an AP math course while in high school earned a STEM postsecondary credential versus 18% of their Pre-Calculus peers and 6% of their Algebra II peers.

Recommendations:

1. Close the opportunity gap for 8th grade Algebra I completion.
2. Develop increasingly rigorous mathematics courses for all four years of high school for ALL endorsement pathways, not just STEM.
3. Provide more offerings in AP and college credit bearing math, especially in non-urban districts.
4. Provide strong advising in high school about college to reduce the share of students enrolling part time.

Pathways of Promise: A Statewide Study of Highest Level of Math Taken in High School and Subsequent Education Outcomes

Pathways of Promise Overview

Pathways of Promise (PoP) is a research and implementation initiative in Central Texas, facilitated by E3 Alliance to *identify and scale Career and Technical Education (CTE) pathways for high school students leading to successful transitions to and completion of a postsecondary credential*. One focus of the research phase in 2014 was to explore the relationship between CTE concentration and education outcomes, with particular attention to those who are traditionally under-represented in higher education (http://e3alliance.org/resource-library-full/).[3] This second critical study paired with this research explored the relationship between the highest level of math mastered in in high school and subsequent education outcomes for students across the state of Texas.

Beginning in 2015 with the implementation phase, E3 Alliance converted the findings from this research into *practical recommendations aligned to district strategies in support of HB 5, professional development to teachers and counselors, and, as needed, curriculum content development to increase course relevance and alignment through college*. In total, this two-year initiative stands to change practices in more than 21 high schools that can improve education outcomes for close to 37,000 students, half of whom are low income.

This brief begins with the set of research questions related to the highest level of mathematics a student mastered while in high school and subsequent education outcomes, including: college and career readiness, college enrollment, college persistence, 2- year to 4-year transfer, college completion and earned STEM postsecondary degree. The methods used to answer these questions, including definitions of key terms such as "mastery," or "part time versus full time enrollment," follow. The third section includes the distribution of mathematics course mastery in high school and findings related to education outcomes based on course mastery. The final section includes an outline of the emerging recommendations arising from these findings, placed in the context of partner district and regional stakeholder priorities.

Research Questions

- What share of students mastered each high school math course evaluated (Geometry, Math Models, Algebra II, Pre-Calculus, Advanced Placement (AP) Statistics, Calculus AB, Calculus BC) as their highest high school math? What is the demographic distribution of this mastery (income, race/ethnicity, gender)?
- What is the relationship between the highest level of math a student masters and later educational outcomes (high school graduation, college and career readiness, college persistence, 2-year-to-4-

year transfer, college completion, earned STEM postsecondary credential (overall and by income, gender, ethnicity)?

- Taking prior achievement and demographics into account, to what degree does mastering a more rigorous math course in high school increase the odds of achieving these outcomes?

Overview of Methods

This study was conducted at the Education Research Center (ERC) at The University of Texas at Austin, a statewide data warehouse mandated by the Texas legislature with longitudinal, student-level, de-identified data from Texas Education Agency, Texas Higher Education Coordinating Board, and Texas Workforce Commission. Each student is provided a unique identifier allowing the data to be linked from early education through 12th grade, higher education and workforce entry.

The analyses examining the relationships between highest high school math course mastered and subsequent education outcomes using data from Texas public school students who were first time 9th graders in 2003-04 and in 2008-09. To allow for the highest possible mathematics mastery, only students who were enrolled in high school for all four years were included. The first cohort (2004 9th graders) enabled longitudinal tracking and analysis through college completion. The second cohort (2009) enabled analysis on students who were in high schools more closely resembling today's high schools in course offerings and school climate. This more recent cohort fell under the "4x4" legislative mandate, requiring high school students to complete four high school credits in each of English Language Arts, Mathematics, Science, and Social Studies.

Researchers opted to focus on mathematics "mastery" of a course rather than "completion" to obtain a more accurate level of a student's knowledge in the given subject. Mastery refers to having passed both semesters of the course (versus the overall average for the year). Analyses of mastery included demographic breakdowns related to income, gender and ethnicity.

It should be noted that, as part of previous research, E3 Alliance examined Algebra I mastery rates for both 8th grade and 9th graders (2012-2013) in Central Texas[4] and found a large gap between the share of non-low income and low income students who completed Algebra I by the end of 8th grade, 43% versus 17% respectively.

As a follow up to the prior research on 8th and 9th graders, this study included specific outcomes related to high school graduation, college and career readiness, college persistence, 2- to 4- year transfer, college completion, and STEM and IT postsecondary credential earned (Appendix A), as defined below.

High School Graduation: Proportion of students from the first time 9th grade cohort who graduate "on time" within 4 years. Note that the findings include only those students who were enrolled in high school for four years.

College and Career Readiness: Percentage of high school graduates who achieve the college readiness level on the 11th grade Texas Assessment of Knowledge and Skills (TAKS) test.

College Enrollment: Students who enroll in the fall and/or spring following their high school graduation.

College Persistence: Students enrolled fall and/or spring in the first year after graduating high school and also enroll in the fall of the second year after high school.

2-year to 4-year Transfer: Students enrolled at a community college in the year after graduation who transfer to a four-year higher education institution by their fall of their 4th year beyond high school graduation.

College Completion: Students enrolled in higher education in the fall and/or spring following high school graduation and who earn a postsecondary certificate, Associate's or Bachelor's degree within 6 years of enrolling.

STEM Postsecondary Credential: Researchers used the North American Industry Classification System (NAICS) to develop the list of postsecondary credentials related to STEM.
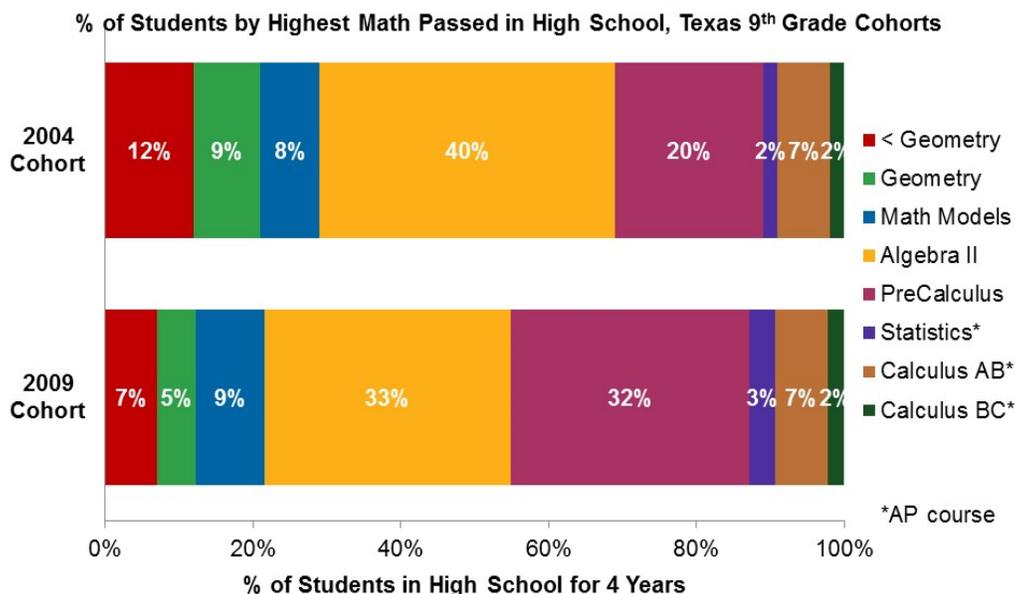
Data Limitations

Data sources available at the ERC include Texas high school students who enroll in Texas public and private institutions of higher education. Students who opt to attend colleges out of state do not have their college data in the data set. As a result, college enrollment, persistence and completion rates are likely to be higher for students in higher level math, especially AP math courses than this study's findings indicate. ERC data also may not include a selection of Texas private not-for-profit colleges and universities – those who do not provide data to the Texas Higher Education Coordinating Board.

Findings Related to the Distribution of Students in HS Math Courses

For the years relating to this study, the typical math course sequence in Texas high schools is: Algebra I, Geometry, Algebra II, Pre-Calculus, AP Calculus AB. Students who struggle with Algebra I and Geometry may take Math Models prior to taking Algebra II. A small selection of students may also opt to take AP Statistics or AP Calculus BC following Pre-Calculus.

As shown in Figure 1, for the members of the 2003-04 9th grade cohort who were enrolled in high school for 4 years, almost 70% mastered Algebra II or lower as their highest math course. Another 20% mastered Pre-Calculus, with only 11% mastering an AP math class (7% Calculus AB). By the 2008-2009 9th grade cohort, as a result of "4x4" state policy, that distribution had shifted dramatically, with 44% mastering Pre-Calculus or higher. For low income students (students qualifying for Free or Reduced-Price Lunch any year of high school), the rate of Pre-Calculus mastery doubled from 14% for the 2004 cohort to 29% for the 2009 cohort. Such increases were seen across ethnicities, as well, indicating an overall shrinking of the achievement gap.

Figure 1

% of Students by Highest Math Passed in High School, Texas 9th Grade Cohorts

2004 Cohort: 12% < Geometry, 9% Geometry, 8% Math Models, 40% Algebra II, 20% PreCalculus, 2% Statistics*, 7% Calculus AB*, 2% Calculus BC*

2009 Cohort: 7%, 5%, 9%, 33%, 32%, 3%, 7%, 2%

Legend:
- < Geometry
- Geometry
- Math Models
- Algebra II
- PreCalculus
- Statistics*
- Calculus AB*
- Calculus BC*

*AP course

% of Students in High School for 4 Years
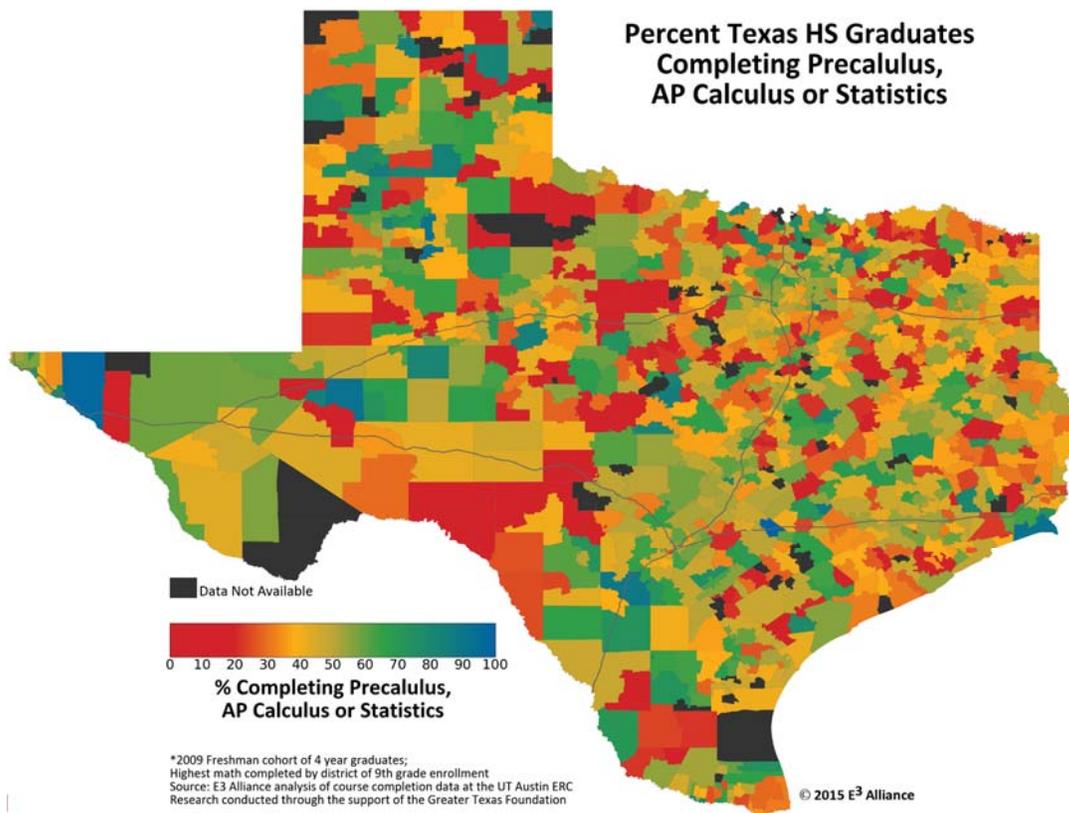
Source: E³ Alliance analysis of PEIMS data at the UT Austin Education Research Center   © E³ Alliance, 2015

Certain disparities persist, however. Students who mastered Pre-Calculus or AP math courses were concentrated in suburban and urban districts. A much smaller share of students in districts in rural and less populated areas mastered these higher level math courses. Figure 2 shows the geographic distribution of students mastering Pre-Calculus or higher across the state of Texas.

Figure 2

Percent Texas HS Graduates Completing Precalulus, AP Calculus or Statistics

Data Not Available

% Completing Precalulus, AP Calculus or Statistics

0 10 20 30 40 50 60 70 80 90 100

*2009 Freshman cohort of 4 year graduates;
Highest math completed by district of 9th grade enrollment
Source: E3 Alliance analysis of course completion data at the UT Austin ERC
Research conducted through the support of the Greater Texas Foundation

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Differences based on ethnicity were also detected in the findings. For example, 75% of Asian students mastered Pre-Calculus or higher level math courses. In contrast, 52% of White students, 39% of Hispanic students and 36% of Black students mastered Pre-Calculus or higher. In addition, 20% of non-low income students mastered AP math classes compared to 7% of their low income counterparts.

Further, males completed less than Algebra II in greater shares than females (26% vs. 17%), and similarly a smaller share of males mastered Pre-Calculus as the highest course (29% vs. 35%). Interestingly, these differences even out for AP math courses at 12% for males and 13% for females.

Findings Related to Educational Outcomes Based On HS Math Courses Mastered

Researchers found a range of educational outcomes associated with the highest level of math mastered while in high school.

High School Graduation: For students in the 2009 9th grade cohort who were enrolled for 4 years and mastered math courses less than Algebra II during that time, high school graduation rates ranged from 56% (for less than Geometry) to 81% (Math Models). Students with Algebra II or greater saw graduation rates ranging from 96% to >99%. Only 54% of low income students with less than Geometry graduated high school within 4 years.

College and Career Readiness: Not surprisingly, students with less than Algebra II mastery showed very low rates of overall college and career readiness; however, only 43% of students *with* Algebra II as their highest level math were college and career ready compared to 70% for Pre-Calculus, 88% for AP Statistics, 92% for Calculus AB, and 95% for Calculus BC. These gaps exist also across ethnicity, with a college and career readiness rate of 60% for Asian students with Algebra II mastery, compared to 32%, 37% and 54% for their Black, Hispanic and White peers respectively.

Gaps in college and career readiness rates based on income also continue across all levels of math, only nearly closing with Calculus BC. A 17 percentage point gap exists between low income and non-low income Pre-Calculus students (62% versus 79% respectively). Overall, females were college and career ready at slightly higher rates than males.

College Enrollment: In general, high school graduates who mastered higher levels of mathematics enrolled in higher education at greater rates than their peers. Fewer than 1-in-4 students with less than Geometry mastery enrolled in college in the year following high school graduation compared to 43% with Geometry and 55% with Algebra II mastery. Seven out of ten students with Pre-Calculus enrolled in higher education. The reported percentage of college enrollment for AP math courses (~75%) likely understates actual enrollment (at the national level) since the data set does not include students enrolling in colleges out of state. When looking only at college enrollment for low income high school graduates, large gaps persist between college enrollment for those who mastered Algebra II (50%) versus Pre-Calculus (68%) and AP Math (~80%).

Importantly, as high school mathematics rigor increases, more students enroll, and more students enroll full time (> 12 credits). For example, almost half of all students completing Algebra II as their highest math enrolled part time, compared to 30% of Pre-Calculus students. Additionally, though low income

students account for nearly half of all students who enrolled in higher education with Pre-Calculus mastery, more than half of this group (56%) enrolled in 2-year (versus 4-year) institutions of higher education, compared to 46% of their non-low income peers who also mastered Pre-Calculus.

Researchers calculated the odds ratios of college enrollment based on highest level math mastered taking into account demographics (income, ethnicity, English Language Learner status, and special education status) and prior achievement (9th grade TAKS performance in mathematics and reading). High school graduates with Pre-Calculus as their highest level of math were almost two times more likely to enroll in higher education than their Algebra II peers.

College Persistence: For the 2009 9th grade cohort who were enrolled in high school all 4 years, 36% who mastered Algebra II as highest math persisted into their second year of higher education, compared to 58% for Pre-Calculus, 68% for AP Statistics, 74% and 72% for Calculus AB and BC respectively. With a more traditional definition of persistence that limits the data to students who had graduated high school and enrolled in higher education, these second year persistence rates were 66% for those who mastered Algebra II, 79% for Pre-Calculus, 89% for Statistics, 92% and 96% for Calculus AB and BC, respectively.

As highest high school level math mastered increases for higher education enrollees, income gaps in higher education persistence rates decrease, though they do not entirely close (see Figure 3). Importantly, for low income college enrollees, higher levels of math mastered while in high school mitigate the gap in college persistence compared to their non-low income peers. For example, 73% of low-income students who mastered Pre-Calculus persist compared to 74% of their non-low income peers who mastered Algebra II. Likewise, 84% of low income students who mastered AP Statistics persist compared to 85% of their non-low income peers who mastered Pre-Calculus (see arrows in Figure 3).

Figure 3
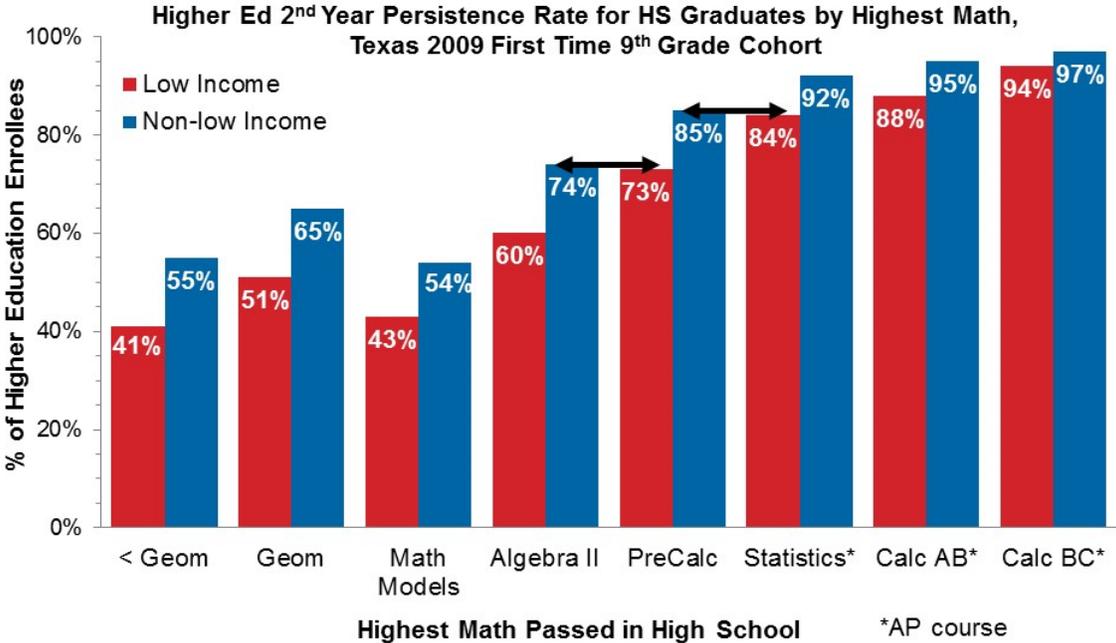
Although the highest level of math mastered in high school shows a clear relationship with college persistence, whether a student enrolls full time versus part time in their first year demonstrates *an even stronger relationship* with whether they persist into the second year. For students who enrolled full time, between 83% (Algebra II) and 98% (Calculus BC) persisted. The rates are far starker for part time students. About half (52%) of Algebra II students who enrolled part time persist to their second year compared to 61% for Pre-Calculus, 67% for AP Statistics and AB Calculus, and 74% for BC Calculus.

2-Year to 4-Year Transfer: Students who mastered Algebra II were the largest group to enroll at a 2-year institution; however, those college enrollees with an additional high school math course beyond Algebra II are more likely to transfer from a 2- to 4- year college. Full-time enrollment, as compared to part-time status, also demonstrated a strong influence on transfer rates.

College Completion: Of the 2004 9th grade cohort who enrolled in higher education, 47% completed within 6 years of initially enrolling (2% earned a certificate, 8% an Associate's degree, 37% a Bachelor's degree). For low income students, 34% completed college within 6 years compared to 54% of their non-low income peers. Overall, only 36% of college enrollees with Algebra II as their highest course completed a post-secondary credential.

Large gaps in completion exist by income even at the highest level of math mastery. For example, 42% of non-low income Algebra II college enrollees completed college within 6 years compared to 28% of their low income peers. A 19 percentage point gap exists for Pre-Calculus and the range for AP math ranges from 14 to 20 percentage points.

Gaps in college completion also exist by ethnicity with Asian and White students experiencing higher rates of completion than their Black and Hispanic peers. This report does not feature findings related to these rates, however, the gaps were found to be comparable to those experienced between non-low income and low income students. For STEM degree completion, numbers were often very low resulting in data masking requirements to protect student privacy.

An analysis of the odds of college completion that took into account demographics and prior performance found that students with Pre-Calculus as their highest level of math were about two times more likely to complete than their Algebra II peers. Students with Calculus had more than three times higher odds of completing than their Algebra II peers and were 80% more likely to complete than their Pre-Calculus peers.

Earned STEM Postsecondary Credential: Figure 4 demonstrates an attrition model (based on education outcomes beginning with high school graduation) of the 2004 9th grade cohort who were in high school all four years. For students who were enrolled in high school for four years, 20% of those with Algebra II as their highest level of math earned a postsecondary degree within 6 years - only 6% completed a STEM degree. In contrast, 46% of students with Pre-Calculus earned a postsecondary degree, with 18% completing a STEM degree. For students with an AP course as their highest math mastered during their four years in high school, 62% earned a postsecondary degree and 31% completed in STEM field. Thus, to have even a modest chance of completing college in 6 years, a high school student would be advised to master at least Pre-Calculus.

Figure 4

Outcomes of Students in HS for 4 Years, Texas 2004 First Time 9th Grade Cohort
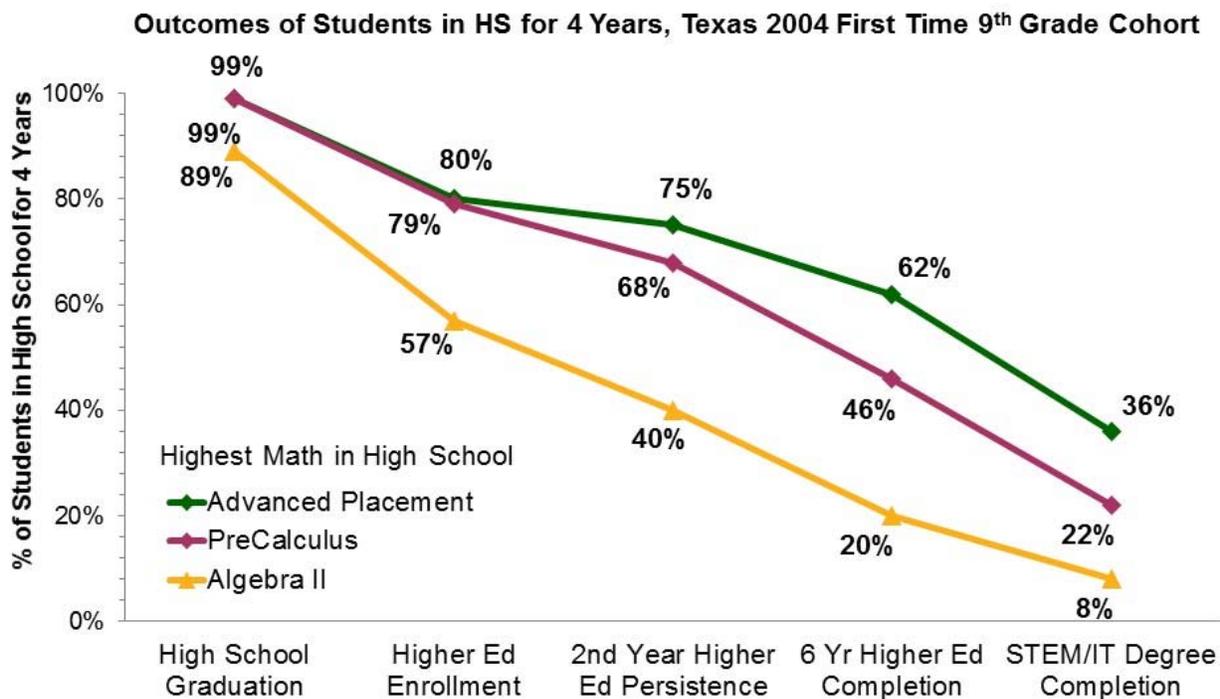
Closing Thoughts and Recommendations

The question of math rigor in high school has become a highly-charged debate in the public arena. The intent of this study is to encourage a data-driven dialogue about the relationship between degree of mathematics rigor and education outcomes. The findings from this study suggest:

1. The relationship between more rigorous math and subsequent positive education outcomes is clear. Pre-Calculus appears to be particularly important for college and career readiness and higher education enrollment, and taking an AP course appears important for higher education outcomes of persistence, 2-to-4 year transfer, completion and STEM degrees. Further research is required to determine if this relationship is a result of student choice based on early intent (i.e., they knew they wanted to go to college so they took math accordingly), improved preparation (i.e., they did not need to remediate in mathematics and therefore were better positioned to succeed in college), and/or other reasons.

2. Other factors beyond mathematics are also involved in subsequent education outcomes. For example, though a much higher percentage of students, including low income students, mastered Pre-Calculus under the 4X4 requirement, there was only a small improvement in low income higher education enrollment rates.

3. A commitment to four years of increasingly rigorous math increases the likelihood of achieving postsecondary success; however, the content of that math may or may not be a factor. Instead, the practice of ensuring that students take increasingly more rigorous math across all of high school may produce the same outcomes. Whether specific math content or rigor is the larger factor could be evaluated if more variety in Advanced Placement and college credit bearing math courses was available to students. This could lead to a further study examining the specific relationship between obtaining college-math credit while in high school and education outcomes.

4. Regardless of the results of a study examining causal underpinnings for increasing math rigor and later academic success, it is clear that establishing a strong mastery of math in early grades (elementary and middle school) – thereby increasing the number and diversity of 8th graders completing Algebra I by the end of their 8th grade year – will help to keep career pathways in STEM and other high wage, high demand fields open to many more students.

5. The findings lead to the following *recommendations*:
   a. Close the opportunity gap for 8th grade Algebra I completion.
   b. Develop increasingly rigorous mathematics courses for all four years of high school for ALL endorsement pathways, not just STEM.
   c. Provide more offerings in AP and college credit bearing math and evaluate their relationships with educational outcomes.
   d. Provide strong advising in high school about college to reduce the share of students enrolling part-time.

Appendix A
Science Technology Engineering and Math (STEM) and Information Technology (IT)
Categories of Majors for Degree Completion

STEM and IT fields-of-study are defined based on the Texas Higher Education Coordinating Board's Classification of Instructional Programs (CIP) codes. Below is the list of CIP codes used to qualify students for STEM or IT postsecondary degree completion.

Aeronautics/Aerospace
Agro-ecology and Sustainable Agriculture
Air Science
Archeology
Architecture and Building Technology
Cognitive Psychology
Computer Information Technology
Computer Science and Support Services
Digital Communications and Media
Education Technology
Engineering
Engineering Technology
Environmental Studies
Gaming, video game design, and interactive technology
Intelligence and Cybersecurity
Management science and quantitative methods
Mathematics
Physical Sciences
Science Technology

Health Science fields were tabulated for this study but not included in the STEM and IT counts. These CIP codes include:

Allied Health Sciences
Behavioral Sciences
Biological and Biomedical Sciences
Medical Sciences

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[1]Wiseman, A. Bailie, C., Gourgey, H. (2015) Pathways of Promise: Student Outcomes in Career and Technical Education Pathways in Central Texas. E3 Alliance: Central Texas.
[2] It should be noted that for AP math courses, lower college persistence rates may be a result of students transferring out of state. The postsecondary education data includes only Texas public and private colleges.
[3] Wiseman, A., et. al. (2015)
[4] *Ibid*.