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Pathways to Mathematics College Readiness in Maine

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This version contains a correction in Table 2.

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Executive Summary

Pathways to Mathematics College Readiness in Maine

The goal of this study was to examine the pathways to being college ready in mathematics. Students who enter high school already having demonstrated mathematics proficiency on a standardized test in the 8th grade have already taken a significant step towards being college ready. The best scenario is to enter high school proficient in mathematics and having already completed Algebra I, then to complete at least Algebra II and Calculus before graduating from high school. Students completing this pathway are virtually guaranteed to be college ready in mathematics.

There also is an alternative path to being college ready. Being proficient entering high school, and then completing a course sequence that includes at least Algebra I, Algebra II, and pre-Calculus significantly increased students' chances of being college ready in mathematics.

Thus, it appears 8th grade proficiency is key to becoming college ready in mathematics. It affords opportunities for students to complete Algebra I before entering high school and then take higher level mathematics courses in high school. Alternatively, even if students wait to take Algebra I in high school, if they are proficient and complete at least pre-Calculus, they have a high likelihood of being college ready. The key is 8th grade mathematics proficiency. It opens the gate to a successful high school and college experience in mathematics.

The typical sequence of courses completed by most high school students is Algebra I, Geometry, and Algebra II. The Common Core State Standards Initiative (2012) has endorsed this three course sequence as preparing students for college. However, the evidence from this study does not support this endorsement. Completing Geometry does not substantially ensure college readiness, nor does completing Algebra II ensure college readiness. Students also need to successfully complete either a pre-Calculus or Calculus course in high school to be college ready.

Pathways to Mathematics College Readiness in Maine

Maine Education Policy Research Institute

University of Southern Maine

In 2009, President Obama set a goal for the United States to have the highest college graduation rate in the world by 2020. He remarked, “In a global economy where the most valuable skill you can sell is your knowledge, a good education is no longer just a pathway to opportunity—it is a prerequisite." There is substantial evidence highlighting the importance and value of earning some type of post-secondary degree. According to the U.S. Department of Labor, over 90% of the fastest growing jobs in the future will require some type of post-secondary education or training (US Department of Labor, 2011). College graduates earn over 74% more than high school graduates (Carnevale, Rose & Chech, 2012), and it is estimated that a college graduate earns over $1 million more than a high school graduate over a lifetime (Northeastern University, 2009).

Today all across the nation, efforts are being made to increase the percentage of high school graduates enrolled in 2- and 4-year colleges and universities. Accompanying these efforts is a growing concern about how well prepared recent high school graduates are to successfully earn a college degree. Nationwide, approximately 60% percent of recent high school graduates enroll in four-year colleges, but only about 60% of these earn a degree within 6 years (NCES, 2010). Many factors may impact college graduation rates, but a key one is academic preparation. In fact, researchers have found that academic preparation is the single strongest predictor of college graduation (Attewell, Heil & Reisel, 2011). Upwards of 40% of college students have to take one or more remedial course and additional evidence indicates that college students who have to take remedial courses have only approximately one in four chances of earning a degree (Wirt, Choy, Rooney, Provasnik, Sen & Tobin, 2004).

In Maine, remediation rates are somewhat lower than the national figures, but the combined University of Maine System and Community College System rate is approximately

30% (UMS, 2013; MCCS, 2013)[1]. Why do so many Maine high school graduates have to take remedial courses? Are they ill-prepared for college? Is it because they take too few courses in key content areas while in high school? Is it how well they perform in their high school courses or the sequence of course they take? Is it the lack of rigor in their pre-college education? This study attempted to answer these questions by exploring the pre-collegiate mathematics preparation of a sample of college undergraduates. It is a second study of a sample of college undergraduates using the Maine State Longitudinal Data System. The first study (Silvernail, Sloan, & Johnson, 2013) explored the college participation rates, persistence, and performance of a cohort of Maine high school graduates.

Methodology

This study examined two groups of students who graduated from Maine public high schools in 2010 and enrolled in a University of Maine System university. Approximately 60% of the 2010 high school graduating class in Maine (n=8293) enrolled in post-secondary institutions in the fall of 2010, and 70% of those stayed in-state. Over one-third of these high school graduates (n=2462) who attended an in-state institution enrolled full-time at a University of Maine System campus.

Although another 30% of the Maine graduates enrolled in post-secondary institutions outside of Maine, this study was limited to students who chose to attend an in-state university, and specifically a University of Maine System university. Although it would have been desirable to study all the 2010 graduates who enrolled in a post-secondary institution, data needed to complete the analyses in this study was only available for University of Maine System enrollees. From the population of over 2400 students who enrolled fulltime in the University of Maine System (UMS) beginning in the fall 2010, 498 enrolled in a remedial math course in their first two years.

[1] Terminology note: In recent years, the term "remedial" has been generally replaced with the term "developmental" in an effort to lessen the stigma associated with the phrase. While recognizing the merit in that substitution, we have opted to retain the phrase "remedial" because the term "developmental" is broader, and often includes not only non-credit courses of interest in this study, but also credit-bearing courses with enhanced academic supports. Additionally, the term "remedial" is often more recognizable and familiar to general audiences.

Two samples were selected for this study. Sample I was a stratified (by UMS institution) sample consisting of approximately one-half (n=240) of all the students who had taken a remedial mathematics course during the first two years of their college career. Sample II was a random sample of students who had not taken a mathematics remedial course in their first two years of college (n=168).

For each group, two key pieces of data were examined. First was the mathematics profile of each student as they entered high school, and second was an analysis of their high school mathematics experience. For each student in both samples, data was compiled on their proficiency level on the 8th grade MEA achievement test and whether they completed Algebra I before the end of 8th grade. In 2009 the MEA tests were replaced with the NECAP, a regional achievement test. The 2010 sample examined in this study was the last group of 8th graders who completed the state MEA test. Based on scores on the MEA test, students were assigned one of four proficiency levels: Does not meet proficiency, Partially meets proficiency, Meets proficiency, and Exceeds proficiency.

The high school transcripts of these two samples were then analyzed. This analysis included determining: (1) the number of mathematics courses; (2) the type and sequence of courses taken by students; and (3) the grades earned in mathematics courses. A preliminary analysis revealed that courses titles varied considerably across Maine high schools making it very difficult to match all courses across the state. Thus, for purposes of this study, the type and sequence of courses was limited to Algebra I, Geometry, Algebra II, pre-Calculus and/or Calculus. Other courses had to be eliminated in further analyses because it was not possible to determine the comparability of these courses across Maine high schools.

The core research questions that guided the analyses were as follows. In comparing the group of students who took a remedial mathematics course with a group who did not take remedial mathematics in their first two years of college:

1. Did the groups differ in terms of the number of high school mathematics courses completed before graduation?
2. Did the groups differ in the grades they earned in their mathematics courses?

3. Did the groups differ in the level of mathematics proficiency demonstrated in the 8th grade?
4. Did the groups differ in the sequence of mathematics course they completed in high school?
5. Did the groups differ in the mathematics courses they completed in the 8th grade?

Each question is explored below, followed by a discussion of the evidence.

Findings

Q1: Did the group of students who took a remedial mathematics course differ from the group who did not take remedial mathematics in terms of the number of high school mathematics courses completed before high school graduation?

Maine high school students are required to complete three credits of mathematics before they graduate, and many students complete more than the equivalent of three yearlong courses. The sequence of courses and the type of courses students complete may vary, but all students are required to complete at least three credits of mathematics to earn a high school diploma.

Table 1 reports the percentage of students in the two study samples who completed three vs. more than three mathematics courses in high school. As shown in the data, there was

Table 1: Number of Years of High School Mathematics

Years of High School Mathematics	Remedial Mathematics Course Takers	Non-remedial Mathematics Course Takers
Three Years	17%	83%
Four Years	17%	83%

no difference in remedial course taking patterns between those high school students who completed three high school mathematics courses versus those who completed four (or more). In both cases, approximately 1 out of 6 students took a college remedial mathematics course, regardless of whether the students completed three or four high school mathematics courses. This suggests that the number of mathematics courses (three or more) completed in high

school is unrelated to the need to complete one or more mathematics remedial college courses.

Q2: Did the group of students who took a remedial mathematics course differ from the group who did not take remedial mathematics in terms of the grades they earned in their high school mathematics courses?

Table 2 reports the performance of students in selected high school courses, by those who did and did not have to take a remedial mathematics course in college. Performance is reported in average scores on a 100 point grading scale in most high schools. The data reveals

Table 2: Performance in Selected Mathematics Courses

Course	Average Course Grade	
	Non-Remedial Mathematics Students	Remedial Mathematics Students
Algebra I	86.9	80.8
Algebra II	86.5	79.7
Pre-Calculus	85.0	79.9
Calculus	85.7	87.2

that there was an average difference of 5-7 grade points for the two groups of students taking Algebra I, Algebra II and Pre-Calculus. For example, students who did not have to take a college remedial mathematics course scored 6.1 points higher in Algebra I than students taking the remedial mathematics course (86.9 vs 80.8). This difference typically translates in the difference between earning a B as compared to a C+ grade. The same pattern is true for Algebra II and Pre-Calculus. However, there was no significant difference in scores for Calculus. Thus, as one might expect, performance in high school mathematics courses is related to having to take remedial mathematics courses in the future.

Q3: Did the group of students who took a remedial mathematics course differ from the group who did not take remedial mathematics in terms of their levels of mathematics proficiency demonstrated in the 8th grade?

To answer this question, students' 8th grade scale scores on the MEA test were examined along with their designated level of proficiency. In terms of MEA scale scores, the analysis revealed that students who did not have to take a remedial mathematics course in college scored 18 points higher (851 vs. 833) than those who did have to take a remedial course, a difference equivalent to 1.5 standard deviations.

Turning to the mathematics proficiency levels of the students in this study, the evidence is very clear. As shown in Table 3, only 8% of those students who had demonstrated proficiency

Table 3: 8th Grade MEA Mathematics Proficiency Levels

Proficiency Levels	Remedial Mathematics Students	Non-remedial Mathematics Students
Does Not Meet	66%	34%
Partially Meets	33%	67%
Meets	8%	92%

in the 8th grade had to take a remedial mathematics course in college. In contrast, *one third* of those students who demonstrated only partially meeting mathematics proficiency in the 8th grade had to take a remedial mathematics course, and *two thirds* of those who did not even partially meet proficiency had to take at least one remedial mathematics course in college. Being mathematically proficient in 8th grade is important not only in a student's high school career but also in the college career.

Q4: Did the group of students who took a remedial mathematics course differ from the group who did not take remedial mathematics in terms of the sequence of courses they completed in high school?

The evidence from the two groups of students analyzed in this study indicates that entering high school being mathematically proficient and having completed Algebra I by the end of 8th grade virtually ensures that the student will not have to take a remedial mathematics course in college. Entering high school with this academic profile prepares these students to take higher level high school mathematics courses while in high school, which further ensures

they are ready for college-level mathematics. As may be seen in Table 4, all those students in the study sample who completed at least Algebra II and Calculus were college ready. None of the students who completed at least Algebra II and Calculus had to enroll in a remedial mathematics course.

Table 4: 8th Grade Proficiency Level and Selected High School Course Sequence

Group	8th Grade MEA Proficiency Level	Mathematics Course Sequence Completed	Remedial Mathematics Students	Non-remedial Mathematics Students
A	Partially Meets	Algebra I, Algebra II	40%	60%
B		Alg I, Geometry, Alg II	41%	59%
C		Alg I, Alg II, Pre-Calculus	22%	78%
D	Meets	Algebra I, Algebra II	24%	76%
E		Alg I, Geometry, Alg II	23%	77%
F		Alg I, Alg II, Pre-calculus	7%	93%
G	Meets	Algebra II, Pre-calculus	4%	94%
H		Algebra II, Calculus	0%	100%

The data in Table 4 bolster the finding that 8th grade proficiency level matters. Comparing similar course sequences for students with different prior proficiency levels (i.e. contrasting group A to group D, B to E, and C to F), the advantage of proficiency is evident.

The data also reveals some interesting information about students who did not take Algebra I until they entered high school. If students entered high school only Partially proficient, then they needed to complete a course sequence of Algebra I, Algebra II, and at least pre-Calculus before they substantially decreased their chances of having to take a remedial mathematics course as they entered college. This can be seen by comparing group C to groups A and B. Even if they completed this sequence, chances were 1 in 4 that they would not be college ready. The same trend can be seen among students who entered high school mathematically proficient; those who completed a course sequence of Algebra I, Algebra II, and pre-Calculus (Group F) greatly decreased their chances of having to take remedial college mathematics compared to the sequences ending with Algebra II (Groups D and E). Their

chances of having to take remedial college mathematics were reduced to less than 10%. So, course sequences were important to being college ready for mathematics.

A particularly interesting finding from the analysis of course sequences is the fact that successfully completing a course in Geometry did not substantially decrease students' chances of having to take a remedial mathematics course in college. For example, 40% of the students who were partially proficient as they entered high school, completed Algebra I and Algebra II, and earned their third high school mathematics credit by taking a non-Geometry course had to complete a remedial course. Virtually the same percent (i.e., 41%) of students who completed Geometry as their third mathematics credit had to take a remedial mathematics course. Although the percentages are lower for proficient students, the pattern was the same. Students completing Geometry or another mathematics course in its place had similar chances of having to take remedial mathematics.

Q5: Did the group of students who took a remedial mathematics course differ from the group who did not take remedial mathematics in terms of the mathematics course they completed in 8th grade?

The data for evaluating this question are limited because it was not possible to document exactly what courses students completed in the 8th grade. However, if some students started their high school career by taking Algebra II, it is safe to assume that they completed Algebra I in the 8th grade. These two groups of students may be seen in Groups F and G in Table 4. Both groups were proficient in 8th grade, and both had overall low rates of remedial math courses. Clearly, being mathematically proficient in the 8th grade decreased a student's chances of having to complete remedial mathematics in college. But the odds that students would not have to take a remedial course were reduced even more, from 7% to 4%, if they completed Algebra I in the 8th grade.

Discussion

The evidence from this study uncovers some key findings relative to being college ready in mathematics. Students who enter high school already having demonstrated mathematics proficiency on the standardized test have already taken a significant step in being college ready:

these students can complete higher level mathematics courses and earn higher grades during their high school career. The best scenario is to enter high school proficient in mathematics and having already completed Algebra I, then to complete at least Algebra II and Calculus before graduating from high school. Students completing this pathway are virtually guaranteed to be college ready in mathematics.

Another key finding is that there also is an alternative path to being college ready. The evidence indicates that being proficient entering high school, and then completing a course sequence that includes at least Algebra I, Algebra II, and pre-Calculus significantly increased students chances of being college ready in mathematics.

Thus, it appears 8th grade proficiency is key to becoming college ready in mathematics. It affords opportunities for students to complete Algebra I before entering high school and then take higher level mathematics courses in high school. Alternatively, even if students wait to take Algebra I in high school, if they are proficient and complete at least pre-Calculus in high school they have a high likelihood of being college ready. The key is 8th grade mathematics proficiency. It opens the gate to a successful high school and college career in mathematics.

Other key findings have implications for the type of courses students complete in high school. The typical sequence of courses completed by most high school students is Algebra I, Geometry, and Algebra II. Many also take other mathematics courses, but these three courses are seen as important for preparing students for college. In fact, The Common Core State Standards Initiative (2012) has endorsed this three-course sequence as preparing students for college. However, the evidence from this study does not support this endorsement. Completing Geometry does not substantially improve college readiness. Furthermore, completing Algebra II also does not ensure college readiness. Students need to successfully complete at least a pre-Calculus course to be college ready. This does not mean completing Geometry is unimportant. Geometry helps students acquire other mathematical skills. But the evidence from this study indicates that Geometry, and even Algebra II, are not sufficient to prepare students for college level mathematics. Students also need to successfully complete either a pre-Calculus or Calculus course in high school to be college ready.

References

Attewell, P., Heil, S., & Reisel, L. (2011). Competing Explanations of Undergraduate Noncompletion. American Education Research Journal 48 (3), 536 -559.

Carnevale, A.P., Rose, S. J., & Cheah, B. (2012). The College Payoff: Education, Occupations, Lifetime Earnings. Washington DC: Georgetown University on Education and the Workforce.

Common Core State Standards Initiative (2012). Common Core State Standards for Mathematics. Appendix A: Designing High School Mathematics Courses Based on the common Core State Standards. Washington DC: Council of Chief State School Officers.

Maine Community College Legislative Report on Remediation Rates (2013) http://www.mccs.me.edu/student/remediationreport.pdf

National Center for Education Statistics (2010). Enrollment in Postsecondary Institutions, Fall 2008; Graduation Rates, 2002 and 2005 Cohorts; and Financial Statistics, Fiscal Year. Washington DC: NCES.

Northeastern University (2009). Left Behind in America: The Nation's Dropout Crisis. Chicago, IL: Center for Labor Market and Alternative Schools Network.

University of Maine System Legislative Report on Remediation Rates (2013). http://www.maine.edu/pdf/LD1645report121712FINAL.pdf

US Department of Labor (2011). Fastest Growing Occupations. Washington, DC: Bureau of Labor Statistics.

Wirt, J., Choy, S., Rooney, P., Provasnik, S., Sen, A., and Tobin, R. (2004). *The Condition of Education 2004* (NCES 2004-077). Washington, D.C.: U. S. Department of Education, National Center for Education Statistics.