



Prioritizing Success for All Students

Maryland Mathematics Pathways



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About the Author

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About Strong Start to Finish

Right now, a first-year student sits in a college classroom being ill-served by remedial math.

And if we fail them, they mostly likely will not earn their degree. There is a persistent trend among students placed in remedial or developmental courses – particularly math and English. They are not completing the courses and, in most cases, should not be taking them in the first place. This should not be their path.

We are a network of like-minded individuals and organizations from the policy, research, and practice spaces who've come together for one reason – to help all students, not just the select few, find success in postsecondary education.

Strong Start to Finish was created to better the chances of low-income students, students of color and returning adult students, to create a fundamental shift in the outcome of their college journey. We have networked higher education leaders, policy entrepreneurs, institutions and technical assistance providers to drive towards an outcome where all students pass their first credit-bearing English and math courses during the first year of study.

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Abstract

Primary Audience:

The primary, though not sole, audience for this publication is a System Chancellor or President of an institution.

Problem Statement:

Long-standing traditional developmental mathematics course sequences have been historically unsuccessful and have negatively impacted student success and completion nationally and in Maryland.

Action:

After determining the actual cost of remedial education, stakeholders, two-year and four-year colleges and universities, worked with state legislators to revise current regulations that appeared to limit the mathematics options for fulfilling general education mathematics requirements. With financial support from the collaboratively developed USDE grant, faculty at multiple institutions in the state worked together to design new courses and new pathways, beginning with a statistics pathway, to reduce remediation in Maryland's higher education institutions.

Context:

Maryland's "P-20" context led to support from higher education leadership to address the public awareness of the increasing cost of remediation. A history of collaboration between two-year and four-year segments created a positive context for policy change. Collecting data (evidence of cost of remediation), engaging all stakeholders through workgroups in changing regulatory language; collaborating on applying for federal grant funding and a commitment to using evidence to scale reform all led to the changes in practice.

Process:

Defining the problem using data led to leadership charging workgroups to develop new regulatory language. The new language opened the door for new pathways courses that were not limited to traditional algebra entry level courses. Collaborative workgroups developed outcomes expectations for new courses and pathways, which served as guidelines for faculty to develop courses that met the new guidelines.

Outcomes:

Two new mathematics pathways were developed for non-STEM majors: Statistics and Topics in Mathematical Literacy. This paper focuses on the statistics pathways implementation.

Sources of Support:

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Introduction

Historically, a college education has often been linked to economic growth and success in life (National Research Council, 2013; Treisman, 2015). Unfortunately, a student’s lack of ability to persist through remedial coursework, particularly in mathematics, can negatively impact college completion. To make matters worse, more students are now entering college underprepared for college-level mathematics (USDE, 2017). As a result, mathematics has been labeled as “too difficult,” and the discipline itself has been depicted as a “barrier” to college completion and certain STEM careers (Bressoud, 2018; Bryk & Treisman 2010; Saxe & Braddy, 2015). This issue is compounded by a perceived lack of relevance and alignment to students’ majors and future career goals. More troubling is the disproportionate number of minority and low-income students who are often placed in developmental mathematics courses (EdSource, 2012), further delaying college completion and potentially widening the achievement gap. In response to this, the state of Maryland has joined a nationwide mathematics pathways movement to better align courses with programs of study while shortening the time to college completion. This Steps to Success Paper will discuss how a shortened statistics pathway was developed and successfully implemented in the state of Maryland so that other states and systems may benefit from this experience.

Context

Location & Student Population

Six community colleges (Anne Arundel Community College, Howard Community College, Montgomery County Community College, Hartford Community College, College of Southern Maryland and Garrett County College) and four four-year institutions (University of Maryland Baltimore County, Towson State University, University of Maryland University College and the University of Baltimore) implemented the statistics pathway and provided student success data.

To be included in the study, students had to score below college-level in mathematics according to each school’s placement test. Because the new pathway focused on non-STEM majors, the study included only students with non-STEM, non-business or undeclared majors. In addition, to ensure that the treatment and comparison groups were equivalent regarding socioeconomic status, the study used Pell grant status as a proxy for student income, as determined by the Free Application for Federal Student Aid (FASFA). Since a requirement of the study was that all participants complete the FASFA in order for a Pell grant determination to be made, this sample possibly included a disproportionate number of low-income students. Both full-time and part-time students, as well as traditional (18-25) and non-traditionally aged students (26-65) were included in the study.¹

TABLE 1- SELECT STUDENT CHARACTERISTICS, BY PERCENTAGE OF SAMPLE

Characteristic	N	Percentage
Gender		
Male	455	36.87%
Female	777	62.97%
Other or Missing	2	0.16%
Race/Ethnicity		
African American/ Black (N=505)	505	40.92%
White (N=455)	455	36.87%
Hispanic (N=241)	241	19.52%
Asian/ Pacific Islander (N=92)	92	7.46%
Alaskan Native/ American Indian (N=24)	24	1.94
Other Race (N=16)	16	1.30%
Missing Race (N=207)	207	16.77%
Age Group		
Under 23	947	76.74%
23 or older	287	23.26%
Pell Status		
Pell eligible	678	54.94%
Non-eligible	556	45.06%

*Notes: N=1,234. Race categories (African American/Black and White) were selected based on the pre-existing race categories from the Maryland Higher Education Commission’s (MHEC) website to align with how Maryland institutions structure their databases to report demographic information to the state. Missing race was added if no demographic information was reported. Ethnicity category (Hispanic) was selected based on the pre-existing ethnicity categories from the MHEC website to align with how Maryland institutions structure their databases to report demographic information to the state. MHEC treats Hispanic ethnicity as a separate overlapping category. Someone could be both White and Hispanic, or both African-American and Hispanic, etc. Students can be categorized as more than one race/ethnicity so percentages may add to more than 100%, and the totals may exceed N=1234.

The main study includes two student cohorts, although only the data from the first cohort is available at this time for presentation and discussion in this paper. This cohort includes students enrolled in a treatment (pathway) or comparison (traditional) course in the summer or fall of 2017. Students were matched by baseline mathematics ability (continuous mathematics placement score) and socioeconomic status (Pell status). After matching, there were a total of 1,234 students (506 in the treatment group and 728 from the comparison group) from the ten institutions that were included in this sample. Table 1 includes basic demographic information regarding the participants in the study.

Policy Factors

Maryland has had a “P-16” context for over twenty years, with the motto: “College begins in kindergarten.” Recently, the context expanded to P-20 to include both college and career outcomes as the overriding goals of state-supported public education. Over the years, five themes have emerged as key priorities: transitions (between K-12 and higher education; between two-year and four-year institutions; between school and workforce); alignment (of student learning outcomes, college readiness and workforce skills); transfer (creating pathways to ensure that students do not lose credits); time to degree (time is money); and affordability.

In 2013, the Maryland General Assembly passed a landmark education bill titled: *College and Career Readiness and College Completion Act (SB740)*.² This new law dictated that all public higher education institutions in Maryland implement policies requiring all enrolled college students to take their credit-bearing mathematics and English general education courses within the first 24 credit hours of study, and that students who are placed into developmental/remedial courses begin those courses during their first semester. The research is clear that the longer students delay taking mathematics courses, the less successful they are (Fike & Fike, 2012). In addition, the new law supported dual enrollment courses and transition courses (remediation in high school) with funding formulas that crossed between K-12 and higher education. State funding for education is a “zero-sum” game. That is, as with any finite

resource, whatever funding is applied to one agency or institution limits what is available for another agency or institution. Thus, building stronger pipelines into college is a way to maximize the impact of funding for education at all levels. The College and Career Readiness Act created a framework for a virtuous cycle and laid a strong foundation for P-20 collaboration: well-prepared students graduating on time leads to cost savings across the board.

Enabling Conditions

Public Awareness Of The Increasing Cost Of Remediation

The landmark 2013 legislation was driven by ongoing data analysis. The state reviewed the numbers of students who were consigned to remedial mathematics and calculated the cost to the state and counties of paying college prices for learning outcomes that should have already been paid for in public schools. The analysis revealed that almost 50% of students enrolled in the public four-year universities (USM, Morgan State University and St. Mary’s University) were taking at least one remedial course, and close to 70% of students at community colleges were as well. According to a study by the Maryland Higher Education Commission, remediation costs almost \$9,000 per student at the public four-years, and \$7,000 per student at the community colleges.³ The costs were staggering and unnecessary, and drained public money that could be used in many more useful and important ways.

Support From Leadership

The cost analysis performed by the Maryland Higher Education Commission, and presented to the Maryland General Assembly in 2016, led to some uncomfortable conversations between the segments. The goal of the exercise was not to level blame, but rather to find solutions. In this respect, Maryland had a ready-made P-20 context to initiate the work.

To begin with, Maryland took advantage of the leadership network that existed between the Chancellor of the University System (Dr. Brit Kirwan) and the Director of the Dana Center at the University of Texas at Austin (Dr. Uri Treisman), two mathematicians who had deep respect for each other

and a shared concern for the urgency of solving the remediation puzzle. Chancellor Kirwan invited Dr. Treisman to be a keynote speaker at a statewide symposium on remedial mathematics, and USM had NSF grant funds to support the meeting. By inviting teams from every public and private two-year and four-year university, as well as teams from the public high schools and State Department of Education, the planning committee was able to convene all the stakeholders to hear the same facts and address the shared statewide challenge. The planning committee carefully and intentionally avoided pointing fingers, and instead, set up the symposium as a working meeting with guided small group discussions and recommendations that were captured. At the end of the day, when the recommendations were shared with the assembled participants, Chancellor Kirwan made a public commitment to lead the work to realign mathematics in Maryland to reduce remediation. Dr. Treisman recommended a strategy of mathematics pathways, and Chancellor Kirwan convened a steering committee of segment heads to guide the work of Maryland Mathematics Reform Initiative (MMRI).⁴

The MMRI Steering Committee charged a workgroup of mathematics experts to study national and state mathematics trends, initiatives, and data and make recommendations for necessary policy changes and future mathematics curricula. The workgroups included faculty from both community colleges and four-year universities, as well as some experts from the Dana Center and representatives from the USM, the Maryland Higher Education Commission, and the Maryland Independent Colleges and Universities Association.

Key to the enabling conditions was the agreement on a shared goal to design mathematics options that came out of the Symposium. The new options were intended to increase success for students in the study of mathematics resulting in a higher percentage of students completing degree programs, while ensuring effective transferability of mathematics credits for students moving from one institution to another.

Willingness To Collaborate Across Higher Education Segments

As previously stated, the MHEC cost analysis, and subsequent hearings in the General Assembly, served as a wakeup call for higher education. The statewide symposium, attended by teams from every higher education institution in the state, and keynoted by nationally recognized speakers, defined clear parameters for a systematic approach to the challenge of reducing remediation. The first task for the established working groups was to understand the limitations and unintended consequences of the current regulatory language defining college level mathematics. The MMRI steering committee charged a small workgroup of two-year and four-year mathematics faculty to revise the state regulatory language for general education mathematics to reflect a new understanding of quantitative literacy and allow for alternative pathways in mathematics education. In the existing regulations, Maryland required all undergraduates to take one course in mathematics “at or above the level of college algebra.” By naming a particular course—college algebra—the regulatory language limited options for pathways. The workgroup offered new regulatory language that was written to open rather than close options. The new language reads: “One course in mathematics, having performance expectations demonstrating a level of mathematical maturity beyond the Maryland College and Career Ready Standards in Mathematics (including problem-solving skills, and mathematical concepts and techniques) that can be applied in the student’s program of study.” That change in regulation was the key to remedial education reform efforts in Maryland.

The Change Process

MILESTONE EVENT 1

Identifying The Problem: Determining The Cost And Impact Of Remedial Mathematics In Maryland

The change process started with data analysis and a data driven definition of the problem. That foundation was important, because it establishes a baseline,

against which any progress can be measured. The first milestone was to determine and agree upon the actual cost and impact of remediation in mathematics. At the request of the Maryland General Assembly, the Maryland Higher Education Commission conducted a cost study of remedial education in FY 2011. The report found that community colleges spend over \$7,000 per remedial student for a total of \$75.3 million. Meanwhile, the USM institutions spend over \$9,000 per student for a total of \$14.0 million on remedial education.⁵

MILESTONE EVENT 2

Engaging Stakeholders

Once the problem had been stated and defined objectively, the second milestone was engaging stakeholders to help solve the problem without casting blame on any segment. Establishing the MMRI Steering Committee and the two workgroups (a mathematics group to study trends and make recommendations, and a group to implement the recommendations) allowed the opportunity for a statewide platform for implementation. How was this accomplished? Because each institution sent a campus team (including mathematics faculty) to the initial convening, each institution had a built-in “campus-based workgroup” that could be deployed to various state-wide meetings on different topics. Having those engaged mathematics faculty made a huge difference as the move to change policy and practice accelerated. The first stakeholder group included mathematics faculty and department chairs from two-year and four-year universities who built a shared awareness and responsibility on their campuses. It is important to note that faculty involvement demonstrated commitment to implementing change from the ground up and not relying on a top down approach. The second stakeholder group was the steering committee of deans and provosts who kept the issue visible at the state policy and legislative levels.

MILESTONE EVENT 3

Establishing The Pathways Coaching Model

The *third milestone* was the revision to the Code of Maryland (COMAR) regulatory language, mentioned previously. The old and new formulations were presented to faculty across the state through shared governance groups in every segment (the Maryland Higher Education Commission, the Maryland Association

of Community Colleges, and the University System of Maryland). The language was refined and revised until all segments felt it incorporated the necessary elements. Most certainly, the “new language” looks like a committee wrote it—but the nuanced, “committee” approach led to the successful approval of the new regulatory language. All segments participated and understood the consequences and implications.

Once the laws had been changed to allow for new pathways, all segments agreed that the collaborations across two- and four-year institutions that were required to write new policy also led to an increased understanding of what it would take to actually build the new pathways. That realization led to the development of the joint proposal to the U.S. Department of Education for a state-wide *First in the World* implementation grant, the *fourth milestone*.

MILESTONE EVENT 4

Applying For Federal Funding

The team that worked on the new regulatory language was the same team that wrote the grant. USM led the proposal writing and submission, and in 2016, won \$3 million dollars from USDE to support the development of the pathways courses and a serious evaluation of the impact of those courses on reducing remediation. The new four-year grant gave the collaborative team a structure and a shared research agenda, engaging 12 institutions as early adopters. The research question was straightforward and to the point: Do students in the new treatment courses (pathway) have better outcomes than students in traditional developmental mathematics courses?

MILESTONE EVENT 5

Addressing Transfer Issues

Milestone five can be best understood as a response to the challenge of ensuring that all the newly developed mathematics courses are transferable. The state is committed to guaranteeing that all general education mathematics courses are equally valuable regardless of where they are taught, taken, and passed. Maryland had a policy dating from the 1980s that requires all Maryland higher education institutions to accept all courses that fulfill general education requirements to transfer between and among all public two-year and four-year

institutions. The purpose of this regulation is to ensure that students do not lose credits when transferring between public colleges and universities. However, the regulation is only as good as the faculty collaboration that ensures common learning outcomes from general education courses. Because the new pathways were opening up new options for mathematics courses that would satisfy the general education fundamental studies requirements, the state had to reconvene disciplinary groups to compare and align learning outcomes for the new courses.

MILESTONE EVENT 6

Using Evidence To Scale Reform

Finally, as the First in the World Maryland Mathematics Reform Initiative (FITW MMRI) project moves through its evaluation stages, the evidence of improved student success will be used to spread a successful model across every public and private two-year and four-year college and university in the state of Maryland, scaling both the model and the successes.

During the past three years, some project partners introduced co-requisite interventions in addition to pathways. In these institutions, co-requisite courses were introduced as part of the statistics pathway sequence. Co-requisite models allow developmental students to take developmental coursework and college-level coursework simultaneously within the same semester, significantly shortening the time it takes to enroll in and complete the college-level mathematics course. These co-requisite courses provide just in time remediation supporting “developmental” students in the credit-bearing course. Montgomery College and Anne Arundel Community College are two institutions which have successfully implemented the co-requisite model in their mathematics programs.⁶ Co-requisite interventions haven been proven to reduce remediation and minimize achievement gaps, particularly in other states such as Tennessee (Denley, 2016). The MMRI partnership is intended to scale best practices and supports multiple models to accomplish that goal. Ultimately, the project will report to the U. S. Department of Education and to the State of Maryland about reduced remediation rates as the pathways work comes to scale.

Outcomes from Change in Practice

The results of the work of the FITW grant are overwhelmingly positive and align with the nationwide success of mathematics pathways across multiple states. After students were matched for baseline mathematics ability and socioeconomic status and adjustments were made for gender, race, ethnicity, institution and when students took the course, matched students were compared in two courses: treatment and comparison. The treatment course was part of the statistics pathway, developed through the work of the grant, and was the final developmental mathematics class that students would take prior to enrolling in a college-level mathematics course in non-STEM programs of study. The comparison course was the final developmental algebra-based or foundational mathematics course within a traditional mathematics course sequence that a student would take prior to taking a college-level mathematics course. Results were presented in terms of each groups’ successful completion of this final developmental course (treatment or comparison).

Overall Changes

When looking at matched students who were placed in a treatment course (part of the FITW statistics pathway) and the comparison developmental mathematics course (traditional pathway) from a summer and fall 2017 cohort, students in the treatment group were significantly more likely to pass the final developmental mathematics course (70.5%) than students in the comparison group (59.2%).⁷ Full-time students enrolled in the treatment class were also significantly more likely to pass their final developmental course than the full-time comparison group (74.5% versus 56.5%). These results were mirrored with the part-time students as well (67.3% versus 60.7%), although the latter difference was not statistically significant

TABLE 2- OVERALL STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=506)	70.5%
Comparison Group/ Traditional Pathway (N=728)	59.2%

*The difference in passing rates between the treatment and comparison group is statistically significant ($p < .001$).

This paper is focused on how state leaders might organize technical assistance and professional development to help colleges at varied levels of readiness to adopt promising practices. Given this focus, it is difficult to point to a direct relationship between statewide actions and changes in student outcomes. While it is inappropriate to attribute improvements on these early momentum metrics exclusively to the activities of the TSC and Texas Pathways, the technical assistance and professional development provided to colleges is undoubtedly a contributing factor.

Equity-Focused Changes

In addition to the success of students overall in the treatment course, students in all demographic categories (race/ethnicity, gender, socioeconomic status) successfully completed the treatment course at a much higher rate than those same students in the comparison group (See Appendix A for data). Likewise, the adjusted success rate between white students in the treatment group (71.9%) versus non-white (69.6%) was not statistically different. Similarly, Hispanic students in the treatment group (71.7%) and non-Hispanic (69.9%) students' success rates for the treatment course were also not statistically different, suggesting that the implementation of the pathway may minimize or even eliminate the achievement gap. These results were also observed when non-white students were disaggregated by race. In particular, differences in success rates by treatment among African American/Black students as well as White students were statistically significant indicating higher success for the statistics pathway course among these groups. Similar results were observed between Pell (69.5%) and non-Pell (71.8%) eligible students. Significant success gains were observed as well for students across the gender divide with larger percentages of students (both male and female) passing the treatment course (67.05% and 72.46% respectively) when compared to the comparison course (53.63% and 62.44% respectively). Collectively, these results show significant potential gains

in student success across multiple demographics for statistics pathway implementation statewide.

It should be noted that when disaggregated by age, results were more complex. Overall, non-traditionally aged students (23 or older) passed both treatment and comparison courses at higher rates than traditionally aged students (22 and younger).

Sources of Support

Technical Assistance Support

From the beginning, with the definition of the problem to be solved, the Dana Center at University of Texas at Austin has been a partner in the work. Chancellor Kirwan reached out to the director, Dr. Treisman for inspiration at the launch of the work. Maryland continued to draw on expertise from the Dana Center throughout the project to support faculty as they developed courses and pathways and to help address challenges to implementation. Challenges included gaps in student advising and faculty's comfort level with new instructional strategies for student engagement. The Dana Center's work is based on two decades of research focusing on K-16 mathematics and science education with an emphasis on strategies for improving student engagement, motivation, persistence and achievement. Under the leadership of Dr. Treisman, the center develops innovative curricula, tools, protocols, and instructional supports that were provided to all participating and affiliate institutions throughout this work.

Grant Support

Close to \$3 million in grant funding from the U.S. Department of Education (FIPSE, Fund for the Improvement of Post-Secondary Education, First in the World) led to the acceleration of the development of courses and programs and the dissemination of the new pathways across 38 colleges and universities by opening access to Dana Center resources to all the public and private colleges within the state. FITW provided the initial funding to develop three key courses/pathways: general education statistics, general education topics in mathematical literacy, and a mathematics pathway

course to short-circuit developmental education. The grant also paid for consulting from Dr. Treisman and the Dana Center, as well as an evaluation by Westat, Inc. The evaluation focuses on three data points: Success or failure in the gateway developmental course (treatment v. traditional), enrollment and success in college-level mathematics (required for graduation), and continued college enrollment.

Other Resources

Every state has unique resources to bring to solve critical issues. Some of Maryland's resources have parallels in many other regions, and others may be unique to this state, but may be seen as intriguing possibilities once they are recognized. Here we highlight two resources in particular: higher education leadership, and the Statewide Mathematics Group (SMG).

Higher Education Leadership

The Chancellor and the Associate Vice Chancellor at the USM collaborated with the executive directors of the Maryland Independent Colleges and Universities Association (MICUA), the Maryland Association of Community Colleges (MACC) and the Secretary of the Maryland Higher Education Commission (MHEC) to provide leadership for this effort. Representatives were present at important meetings, kept the topic of mathematics pathways on the agendas of their segmental governing board meetings, and used common language when describing the pathways work to their boards and to the state legislature.

Maryland's State-wide Mathematics Group (SMG)

This longstanding, voluntary association, co-led by a mathematics professor from University of Maryland College Park and a mathematics professor from Howard Community College is the "secret sauce" that makes the Maryland mathematics landscape navigable and collaborative. Problems are put on the table and addressed directly, face-to-face in full view of a convening of mathematics faculty and placement directors. The group was started in 1994 as a collaboration between two-year and four-year mathematics faculty who were charged to work on creating seamless transfer for students completing general education mathematics requirements at community colleges. Faculty changes come and go,

but the "statewide mathematics group (SMG)" continues, because everyone who attends perceives value in the connectivity. All two-year and four-year colleges and universities, both public and private, participate in the SMG. The original collaborations included alignment of course outcomes, sharing of syllabi, and discussion of placement practices. Over the more than 30 years since the implementation of the original state regulations regarding the transfer of general education courses, the group has persisted, in large part because they found the opportunity to collaborate was a valuable resource for faculty, departments and state policymakers

Moving Forward

Lessons Learned

Looking ahead, it is first important to recognize how far we have come in our mathematics reform efforts. Before we project next steps, we wanted to identify three lessons that we learned along the way that shape our current thinking.

Questioning "College Algebra For All"

One of the lessons learned from this work is that nationally, we have long imposed the ineffective practice of requiring college algebra for all students regardless of their selected major. As a result, students have been required to take mathematics courses that in many cases were unnecessarily difficult and/or contained extensive mathematical content that was not relevant or aligned to their program of study. This left students with too many choices and created barriers for many students (particularly students of color and low-income students) making it more difficult for them to complete a college education. The implementation of mathematics pathways at scale in the state is the first step to addressing this issue head on.

Engaging Early With Advising

One of the things that most surprised us was that advisors had a more difficult time than mathematics faculty accepting and implementing the mathematics pathways. We found that in most institutions that participated in the study, the advisors wanted to be more conservative and provide students with more choices through the traditional college algebra pathway which allows them

mathematical access to all majors. The resistance among advisors to embrace and champion the new mathematics pathways helped us to understand the importance of engaging with advising early in the change process so that they can buy-into the rationale and effectively communicate the benefits to students. To address this challenge in the future, we would recommend engaging with advisors and student services staff early in the process to help them understand the potential benefits to students and to secure buy-in well in advance of pathway implementation.

Engaging The Entire Spectrum Of Higher Education In The State

Although the project began with 12 institutions, the data collected, workshops and professional development opportunities provided through the FITW grant were immediately opened up to allow all state institutions (public and private, two and four-year) to participate. Institutions that were not formally part of the original 12 were labeled as affiliates and received all communications and full access to any non-financial support provided through the grant. There are currently 27 institutions of higher education out of a total of 39 Maryland institutions actively engaged in the pathways work as a grant-supported or affiliate institution.

Next Steps

We began the work by conducting a data-driven needs assessment which helped us understand both the financial and human cost of the existing system of mathematics placement/remediation and laid the foundation for change. While we were fortunate to have won external resources to initiate the work, the initial needs assessment was so compelling that the state would have pressed forward with this work even without the funding. The FITW grant allowed us to speed up our timeline and conduct the rigorous research and evaluation to collect evidence to ground the conclusions. Leadership across multiple higher education segments, buy-in from the academic mathematics community, and engaging the advising community were highly important aspects of the project. The grant funds end in 2019, but the momentum of the work will continue.

The next steps for the state include disseminating information and results statewide and implementing the pathways in all institutions across the state. We will also continue to monitor the transfer pipeline, making sure that students take full advantage of the multiple pathways to earning a college degree or credential. As a result of the infrastructure that has been established through the work of the grant, the collaboration across the state and the network of support, Maryland also hopes to develop other collaborative grant proposals to include the implementation of additional mathematics pathways. Depending on resources, we would look to expanding the work into the K-12 schools, where foundational mathematics is taught. Our goal is to successfully accomplish full implementation of pathways and other aligned interventions (co-requisite models) at scale, increase student success and completion and minimize and/or eliminate the achievement gap in mathematics.

Appendix A: Tables

TABLE 3 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE MALE AND UNKNOWN GENDER STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=207)	67.05%
Comparison Group/ Traditional Pathway (N=205)	53.63%

*The difference in passing rates between the treatment and comparison group is statistically significant ($p < .05$).

TABLE 4 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR FEMALE STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=299)	72.46%
Comparison Group/ Traditional Pathway (N=478)	62.44%

*The difference in passing rates between the treatment and comparison group is statistically significant ($p < .05$).

TABLE 5 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR BLACK/ AFRICAN AMERICAN STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=206)	63.38%
Comparison Group/ Traditional Pathway (N=299)	54.33%

*The difference in passing rates between the treatment and comparison group is statistically significant ($p < .05$).

TABLE 6 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR WHITE STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=288)	71.92%
Comparison Group/ Traditional Pathway (N=227)	62.90%

*The difference in passing rates between the treatment and comparison group is statistically significant ($p < .05$).

TABLE 7 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR HISPANIC STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=65)	71.67%
Comparison Group/ Traditional Pathway (N=176)	62.69%

*The difference in passing rates between the treatment and comparison group is NOT statistically significant, $p < .05$. However, please note very small Ns.

TABLE 8 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR ASAIN/ PACIFIC ISLANDER STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=35)	84.13%
Comparison Group/ Traditional Pathway (N=57)	64.13%

*The difference in passing rates between the treatment and comparison group is NOT statistically significant, $p < .05$. However, please note very small Ns.

TABLE 9 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR ALASKAN NATIVE/ AMERICAN INDIAN STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=8)	40.78%
Comparison Group/ Traditional Pathway (N=16)	48.36%

*The difference in passing rates between the treatment and comparison group is NOT statistically significant, $p < .05$. However, please note very small Ns.

TABLE 10 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR PELL ELIGIBLE STUDENTS BY TREATMENT⁸

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=282)	69.5%
Comparison Group/ Traditional Pathway (N=396)	58.1%

*The difference in passing rates between the treatment and comparison group is statistically significant ($p < .05$).

TABLE 11 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR PELL NON-ELIGIBLE STUDENTS BY TREATMENT⁸

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=224)	71.8%
Comparison Group/ Traditional Pathway (N=332)	60.6%

*The difference in passing rates between the treatment and comparison group is statistically significant ($p < .05$).

TABLE 12 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR TRADITIONAL (22 OR YOUNGER) STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=413)	67.8%
Comparison Group/ Traditional Pathway (N=534)	55.1%

TABLE 13 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR TRADITIONAL (23 OR OLDER) STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=93)	78.6%
Comparison Group/ Traditional Pathway (N=194)	72.4%

TABLE 14 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR FULL-TIME STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=227)	74.5%
Comparison Group/ Traditional Pathway (N=256)	56.5%

*The difference in passing rates between the treatment and comparison group is statistically significant, $p < .05$.

TABLE 15 - STUDENT SUCCESS IN FINAL DEVELOPMENTAL COURSE FOR PART-TIME STUDENTS BY TREATMENT

Treatment Group	Adjusted Percentage of Students Who Successfully Passed Final Developmental Course
Treatment Group/ Statistics Pathway (N=134)	67.3%
Comparison Group/ Traditional Pathway (N=299)	60.7%

*The difference in passing rates between the treatment and comparison group is statistically significant, $p < .05$.

Appendix B: Site Context

What is the name of the institution(s), and if appropriate system, where the changes in practice took place?

Anne Arundel Community College, Howard Community College, Montgomery County Community College, Hartford Community College, College of Southern Maryland, University of Maryland Baltimore County, Towson State University, University of Maryland University College and the University of Baltimore

In which state(s) is/are your institution/system located?

MARYLAND

At which type of institution(s) did this change in practice take place?

4-year and 2-year public

What is the total, undergraduate (headcount) enrollment for the institution(s) where the change in practice took place?

Table A-1. Undergraduate Headcount, by Institution: Fall 2017 and Fall 2018

Institutions	Fall 2017 total undergraduate headcount	Fall 2018 total undergraduate headcount	Total undergraduate headcount (Fall 2017 and 2018)
4-year Public			
University of Baltimore	2,949	2,569	5,518
Towson State University	19,596	19,818	39,818
University of Maryland University College	45,604	47,253	92,857
University of Maryland Baltimore County	11,234	11,260	22,494
2-year Public			
Anne Arundel Community College	13,354	12,354	26,240
Cecil College	2,458	2,388	4,856
College of Southern Maryland	7,061	6,882	14,083
Garrett College	673	658	1,279
Hartford Community College	6,109	5,865	11,938
Howard Community College	9,723	9,462	18,938
Montgomery College	22,875	21,720	44,595

Source: MACC Databook 2018 and USM Institutional Research Information System

What percentage of full-time, beginning undergraduate students received a Pell Grant?

Table A-2. Percentage of First-time, Full-time Freshmen Receiving Pell Grants, by Institution: Fall 2017 and Fall 2018

Institutions	Fall 2017 % full-time first-time Freshman Receiving Pell	Fall 2018 % full-time first-time Freshman Receiving Pell
4-year Public		
University of Baltimore	62%	n/a until 2019
Towson State University	29%	n/a until 2019
University of Maryland University College	44%	n/a until 2019
University of Maryland Baltimore County	25%	n/a until 2019
2-year Public		
Anne Arundel Community College	28%	20%
Cecil College	35%	45%
College of Southern Maryland	28%	23%
Garrett College	61%	60%
Hartford Community College	28%	32%
Howard Community College	34%	36%
Montgomery College	36%	43%

Source: MACC Databook and USM Institutional Research Information System

Note: Percentage receiving Pell for community college if from Fall 2015 - Most recent data from FAIS.

What percentage of students are African American/ Black?

See Table A-3 for the breakdown of the institutions

What percentage of students are American Indian/ Alaskan Native?

See Table A-3 for the breakdown of the institutions

What percentage of students are Asian/Pacific Islander?

See Table A-3 for the breakdown of the institutions

What percentage of students are Hispanic or Latinx?

See Table A-3 for the breakdown of the institutions

What percentage of students are More than One Race?

See Table A-3 for the breakdown of the institutions

What percentage of students are White?

See Table A-3 for the breakdown of the institutions

What percentage of students are aged 24 or under?

See Table A-3 for the breakdown of the institutions

What percentage of students are aged 25 or older?

See Table A-3 for the breakdown of the institutions

Table A-3: Demographic Characteristics, by Institution

4-year Public Institution				
	University of Baltimore	Towson State University	University of Maryland University College	University of Maryland Baltimore
% of African American/ Black students	47.10%	20.78%	26.22%	18.05%
% of American Indian/ Alaskan Native students	.51%	.18%	.48%	.20%
% of Asian/ Pacific Islander students	5.02%	5.97%	5.48%	21.65%
% of Hispanic/ Latino students	3.83%	7.77%	13.02%	7.38%
% of more than one race students	4.48%	4.85%	4.72%	4.32%
% of White students	31.54%	56.52%	40.20%	41.13%
% age 24 or under	49.10%	88.33%	24.30%	84.72%
% age 25 or older	50.66%	11.67%	75.67%	15.28%
2-year Public Institution				
	Anne Arundel Community College	Cecil College	College of Southern Maryland	Garrett College
% of African American/ Black students	17%	10%	25%	21%
% of American Indian/ Alaskan Native students	0.3%	0.3%	0.4%	0.1%
% of Asian/ Pacific Islander students	5%	2%	4%	0%
% of Hispanic/ Latino students	8%	6%	7%	2%
% of more than one race students	4%	5%	6%	2%
% of White students	58%	77%	57%	74%
% age 24 or under	65%	72%	73%	90%
% age 25 or older	35%	28%	27%	10%
2-year Public Institution (continued)				
	Harford Community College	Howard Community College	Montgomery College	
% of African American/ Black students	16%	29%	27%	
% of American Indian/ Alaskan Native students	0.3%	0.3%	0.3%	
% of Asian/ Pacific Islander students	3%	12%	12%	
% of Hispanic/ Latino students	5%	10%	25%	
% of more than one race students	4%	5%	3%	
% of White students	70%	35%	23%	
% age 24 or under	74%	65%	69%	
% age 25 or older	26%	36%	31%	

Notes

- ¹ Students who did not qualify for the study were still permitted to enroll in the course. However, their data were not used in the study.
- ² <http://mgaleg.maryland.gov/2013RS/bills/sb/sb0740E.pdf>.
- ³ <http://mgaleg.maryland.gov/pubs/budgetfiscal/2016fy-budget-docs-operating-hepb1-higher-education-policy-briefing---remediation.pdf>.
- ⁴ <http://dcmathpathways.org/resources/first-world-maryland-mathematics-reform-initiative-fitw-mmri-project-overview>
- ⁵ <http://mgaleg.maryland.gov/pubs/budgetfiscal/2016fy-budget-docs-operating-hepb1-higher-education-policy-briefing---remediation.pdf>
- ⁶ Hamman, John, et al, A tale of two corequisites: Integrating foundational skills and statistics in forthcoming volume, Math pathways in Maryland: Stories from the field (working title), in press.
- ⁷ All passing rates in this section have been statistically adjusted for differences in SES, baseline math ability, and demographics.
- ⁸ Because the Pell Grant X Treatment interaction was not significant, the treatment works the same for high- and low-income students.

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