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Chapter 8

Counting on Our Future:

First in the World (FITW) Maryland Mathematics Reform Initiative (MMRI)

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Abstract

The Maryland Mathematics Reform Initiative (MMRI) is a collaborative effort between the public four-year University System of Maryland institutions and the community colleges in Maryland to develop and implement multiple, high-quality mathematics pathways. The focus is on the mathematics that is relevant for students' chosen career paths, while also ensuring that new courses have sufficient mathematical integrity and rigor to be deemed "college level." This chapter presents a case study of the MMRI and the state's efforts in undergraduate mathematics reform. The work in Maryland is presented chronologically and details the evolution of the state's mathematics goals and process for regulatory and policy change. The implementation of an ongoing postsecondary developmental pathways reform project is highlighted along with implications for other states and systems looking to make similar reforms.

Setting Maryland's State-Level Higher Education Mathematics Policies

Mathematics reform in Maryland is a process of continuous revision that requires consideration of all levels along the P-20 continuum, that is, education from pre-school through graduation and entrance into the workforce. The work in the state has historically considered evidence of need and responded with raised standards and changed policies. Current work to reform undergraduate mathematics is focused on postsecondary developmental-level coursework.

Completion of a college degree is associated with better economic, social, psychological, and medical outcomes than not (The College Board, 2013; Pew Research Center, 2014). Further, there is major cost savings potential for systems and states that reform postsecondary developmental mathematics. Mathematics success is linked to college success (Hagedorn, Cabrera, & Prather, 2010), and traditional developmental education, which entails a series of courses leading to and through algebra and calculus, is costly. Maryland community colleges spend about $7,000 per student for developmental education, and the University System of Maryland (USM) spends about $9,000 for each four-year student. Half of all USM students begin in community colleges, and 71 percent of Maryland's community college students test into developmental mathematics (Maryland Department of Legislative Services, 2012; Maryland Higher Education Commission, 2013).

Success in developmental coursework has implications beyond degree completion. The imperative to reform developmental mathematics is evident in recent research on enrollment patterns and college completion. Students from the lowest income quartile have less than an 8 percent chance of ever earning a college degree, while their wealthier counterparts have an 82 percent chance of completion (Lynch, Engle, & Cruz, 2011). The obstacle many of these students face is the need for remediation, often called developmental coursework, designed to remove deficiencies in mathematics knowledge and skills needed to be successful in college-level classes (Executive Office of the President, 2014; Rath, Rock, & Laferriere, 2013). Developmental coursework does not count toward degree completion, although enrollment usually costs the same and class attendance takes up the equivalent amount of time of a credit-bearing class (Knepler, Klasik, & Sunderman, 2014).

While research has shown developmental coursework to be "highly effective at resolving skill deficiencies," the "majority of remedial students do not remediate successfully" (Bahr, 2008b, p. 421). In fact, Bahr found that just one-fourth of remedial students move successfully to a college-level course, and one-fifth actually complete a credential or transfer. Further, students who were unsuccessful in developmental courses were unlikely to make long-term academic progress in general. Developmental mathematics has been identified as a dead end for the majority of students who test into it. Anthony Bryk of the Carnegie Institute for the Advancement of Teaching has called intermediate algebra the academic graveyard for non-STEM majors (Merseth, 2011). Indeed, just 27 percent of students enrolled in Intermediate Algebra ever complete a degree (National Center for Education Statistics, 2013).

In response to the challenges highlighted above, Maryland developed the goals for undergraduate mathematics below (Maryland State Department of Education, 2004). The remainder of this chapter discusses the origin of the goals, and expands upon our particular policy context and how leaders over time have grappled with "the magnitude of the change" (Berry, Ellis, & Hughes,

2014, p. 564) needed to have positive effects at the micro and macro levels. Policy takeaways that might be applied to other systems or states are also presented. This chapter shares the effort in Maryland to move from opportunities to new policy, to practice, and to a theory of action, to achieve the following goals for undergraduate mathematics:

1. to reduce the number of students taking remedial mathematics,
2. to increase the percentage of students who successfully complete remedial mathematics within their first year of college,
3. to increase the percentage of first-year freshmen who successfully complete a mathematics course that fulfills a general education requirement in their first year,
4. to develop mathematics pathways to place students in more appropriate courses for their educational goals and for success in their degree program area, and
5. to provide better advising for incoming freshmen and returning non-traditional students.

History and Context for Mathematics Reform in Maryland

Higher education mathematics reform in Maryland has a long history that began in the mid-1990s when the Statewide Mathematics Group (SMG), comprising college mathematics professors, reviewed K–12 teaching goals and noted gaps in content that inhibited students from being successful in college mathematics courses. In response in 1999, the Maryland State Department of Education (MSDE) tasked a collaborative group of secondary and college educators, called the K–16 Council, to oversee the development of *Bridge Goals*, mathematics goals that would bridge the gap between the state's *Core Learning Goals* and credit-bearing college mathematics goals (MSDE, 2004). The K–16 Council convened Bridge Goal Task Forces between 1999 and 2004 to study the links between secondary and college-level mathematics. Large-scale studies of student performance were conducted to determine the connection between high school, developmental, and credit-bearing mathematics courses. These studies confirmed the link between taking mathematics in the senior year of high school and students' success in the first college mathematics course in the following year. These findings, linking high school math-taking patterns to college success, have been echoed in many other studies around the country (e.g., Hagedorn et al., 2010) and had a direct effect on higher education policy in the state. Admissions standards for all University System of Maryland institutions were revised to require four years of mathematics in high school.

New Policy, New Opportunity

Building on the work of the state's mathematics community, Maryland's General Assembly passed the College and Career Readiness and College Completion Act of 2013, which formulated a coherent policy linking K–12 school reform with postsecondary student success (Maryland Association of Community Colleges, 2013). Under this landmark legislation, all public higher education institutions in the state must ensure that all enrolled students take their credit-bearing mathematics and English general education courses within the first 24 credit hours of study. In addition, institutions are required to ensure that students begin their developmental courses sequences, if applicable, during their first semester. In an effort to develop an implementation plan, representatives from Maryland's P–20 education sectors partnered to create a day-long conference in 2014 for faculty, K–12 teachers, administrators, and policy leaders

to identify which quantitative literacy skills undergraduate students need for future success (USM, 2014). Dr. Uri Treisman, executive director of the Dana Center, delivered the keynote address and challenged education leaders to answer the question: "What does quantitative literacy mean for Maryland education and what systemic changes are needed?"

As a direct result of the 2014 conference, University System of Maryland Chancellor Dr. Brit Kirwan created the Maryland Mathematics Reform Initiative (MMRI), appointing a steering committee of mathematics experts to study national and state mathematics trends, initiatives, and data and make recommendations for necessary policy changes and future mathematics curricula in Maryland higher education. The intended outcome of the reform initiative was for Maryland institutions to design mathematics options that yield (a) increased success for students in the study of mathematics, (b) a higher percentage of students completing degree programs, and (c) effective transferability of mathematics credits for students moving from one institution to another. The steering committee was charged with developing student expectations and institutional processes.

The MMRI steering committee observed a significant, underlying problem with traditional developmental mathematics course sequences: the "disconnect" between the mathematics content students were learning in their general education mathematics courses and the mathematics students need to be successful in their majors. In fact, the state's former regulatory language identified college-level mathematics as "college algebra and above" (see Code of Maryland Regulations, 2017, Table 1). As a result, most institutions enrolled students in the intermediate algebra developmental sequence with the expectation that all students, regardless of major, would complete a calculus-based mathematics course to fulfill the general education requirement. The steering committee charged a 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 mathematical education.

Table 1. Maryland state regulatory language on college mathematics

Old Language	New Language
One course in mathematics at or above the level of college algebra	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)

From Policy to Practice to Action: FITW MMRI

The MMRI continues as a collaboration between the public four-year USM institutions and the two-year community colleges in the state to develop and implement multiple high-quality mathematics pathways for students that are relevant for their chosen career paths while also ensuring that the new

courses have sufficient mathematical integrity and rigor to be deemed college level. As part of the statewide MMRI steering committee work, the University System of Maryland applied for and was awarded a five-year grant in 2015 from the U.S. Department of Education's First in the World (FITW) program to develop, implement, and evaluate a statistics pathway to accelerate developmental students' progress into credit-bearing postsecondary courses and to help more of those students reach certificate or degree completion effectively and efficiently (United States Department of Education, 2015). Project goals are in support of the SMG's goals for undergraduate mathematics and include reducing costs for students who will not have to languish in developmental courses, and saving the state and higher education institutions at least a portion of the estimated $72 million spent annually in Maryland on developmental education (Alliance for Excellent Education, 2011). To meet those goals, the FITW MMRI program supports the development of a new developmental statistics pathway that leads to a general education statistics course. The 12 partnering institutions include five USM four-year institutions and seven two-year community colleges, serving approximately 158,000 new students each year.

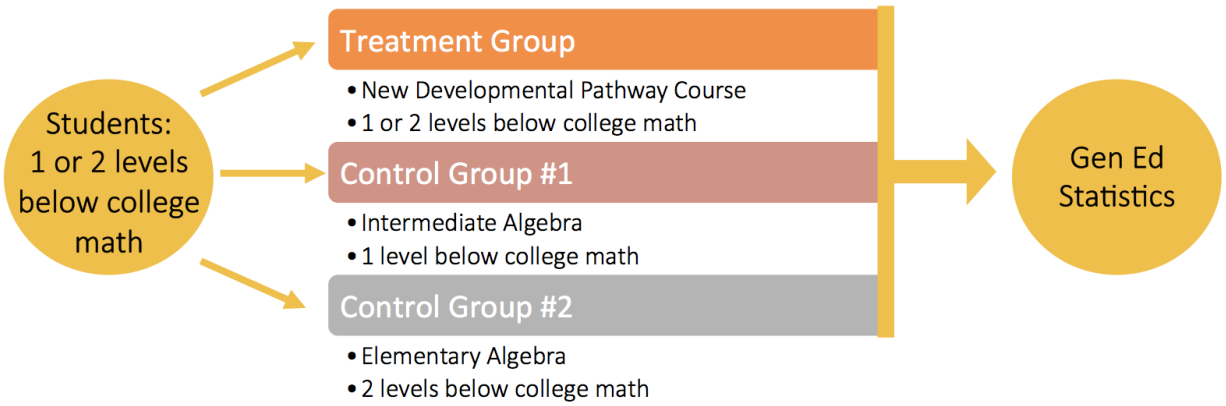
The FITW MMRI project is based on the same hypothesis that led to regulatory changes in the state's definition of general education mathematics: that there is a disconnect between the mathematics content students are learning and the mathematics they need to be successful. This hypothesis led to a holistic approach to reform developmental mathematics that addresses both the structural sequence and the content of the courses. This is a fairly new approach in that most reform efforts have focused either on redesigning course structure and sequence (Hanover Research, 2013; Twigg, n.d.) or on creating co-requisite developmental supports while students stay enrolled in college-level classes (Vandal, n.d.). The FITW MMRI's systemic approach is supported by research that states such is more likely to affect college completion rates than would reform of discrete programs or individual courses (Bailey, Jaggars, & Jenkins, 2015).

The key intervention in the project focuses on a rigorous pathway in statistical reasoning. In the FITW MMRI theory of action, the new pathway would be more appropriate, more relevant, and more useful for students who are either undecided about their major or whose college major relies on an introductory, credit-bearing statistics course either in place of, or in addition to a traditional college algebra course. The new statistics pathway is a single, intellectually rigorous developmental statistics course that meets the needs of students who may be one to two levels below college-level mathematics and for whom a calculus-based, college-level mathematics is less relevant to their intended major, followed by a college-level statistics course. The new statistics pathway is a strategy that would potentially reduce barriers (costs and time associated with taking multiple developmental-level mathematics courses) to college credit accumulation and successful completion of a postsecondary degree.

FITW MMRI Research Questions

One research goal for FITW MMRI is to determine the effects of a newly designed mathematics pathway on student rates of enrollment and success in a college-level statistics course, college retention, and persistence towards degree completion compared to a matched comparison group of students who take traditional developmental algebra courses (see Figure 1).

Figure 1. Developmental pathways for students: traditional vs. statistics pathway



The success of this new statistics pathway is dependent on a set of design elements that support creation of a new institutional infrastructure, supports for faculty teaching the pathway courses, and supports for students who are placed in developmental mathematics. The critical design elements include an institutional liaison, a mathematics content faculty fellow, an assessment faculty fellow, an advising liaison, and a data or institutional research representative for each partner institution. These elements represent what Bailey et al. (2015) referred to as holistic and broad-based participation in a pathways reform effort:

- *Institutional liaisons* serve as the institutional administrative leaders for the mathematics reform work and are responsible for coordinating all project activities on the campus. Specific duties of institutional liaisons include coordinating professional development opportunities for faculty.
- *Mathematics content faculty fellows* provide the academic and intellectual leadership for mathematics content and innovations in teaching.
- *Assessment faculty fellows* develop common summative assessment items that are used to validate the academic rigor of the new pathway.
- *Advising liaisons* serve the critical connection of the institutional advising community to the FITW MMRI pathway. Advising is particularly influential on developmental student success, especially for students aiming to transfer from one institution to another. Effective advising has been found to have a significantly positive effect on student persistence (Bahr, 2008b; Pascarella & Terenzini, 2005; Seidman, 1991), with more impact on students in need of remediation (Bahr, 2008a).
- *Data or institutional research representatives* are critical to ensuring that the project collects, protects, and maintains all data that are necessary to measure the overall impact of the new pathway on student persistence and graduation.

The impact of the FITW MMRI is currently being measured as the project is implemented across the state. This research will add to what is understood about the effects of the mathematics pathways on students' future academic performance. However, it is expected that findings will have implications beyond mathematics; anecdotal evidence shows the positive effects of changed pathways and changed teaching habits on student outlook. Our future research will focus on exploring how to sustain successful innovations despite challenges such as campus faculty and staff turnover, institutional administrative layers/bureaucracy, and severed or historically tense lines of communication between and within institutions.

Conclusion

At the writing of this chapter, FITW MMRI has completed its pilot implementation year and is beginning the first year of statewide implementation. During this short time, it has been concluded that to move large-scale policy into the implementation phase, policy and implementation work need to be grounded in the three key foundational ideas:

- common understanding of the problem(s),
- shared belief in the significance of the problem(s), and
- institutional leadership and faculty buy-in.

Of the three foundational ideas, strong institutional leadership and faculty buy-in are the greatest potential challenge. In Maryland, the mathematics faculty members have a long history of meeting and working together in open, frank discussions about higher education mathematics teaching and learning. Buy-in from this faculty group has been critical in moving the new pathway forward. The success of new mathematics pathways policies is also dependent on a state's or institution's capacity to provide resources for faculty, advisors, and other necessary support professionals to design, implement, and sustain the new pathway, while keeping the larger higher education community engaged in the progress of the work. Collective, collaborative action, informed by research on how students learn mathematics best, is Maryland's goal for the future.

Bringing together the entire mathematics community in the state of Maryland to focus on student success in mathematics and college completion is the main component of being First in the World!

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