Math Pathways Reforms in Maine

Prepared by:

Sarah B. Jessen

Amy F. Johnson

February 2020

Maine Educational Policy Research Institute (MEPRI)

University of Southern Maine

Gorham Maine

**Center for Education Policy,
Applied Research, and Evaluation**

Published by the Maine Education Policy Research Institute in the Center for Education Policy, Applied Research, and Evaluation (CEPARE) in the School of Education and Human Development, University of Southern Maine.

CEPARE provides assistance to school districts, agencies, organizations, and university faculty by conducting research, evaluation, and policy studies.

In addition, CEPARE co-directs the Maine Education Policy Research Institute (MEPRI), an institute jointly funded by the Maine State Legislature and the University of Maine System. This institute was established to conduct studies on Maine education policy and the Maine public education system for the Maine Legislature.

Statements and opinions by the authors do not necessarily reflect a position or policy of the Maine Education Policy Research Institute, nor any of its members, and no official endorsement by them should be inferred.

The University of Southern Maine does not discriminate on the basis of race, color, religion, sex, sexual orientation, national origin or citizenship status, age, disability, or veteran's status and shall comply with Section 504, Title IX, and the A.D.A in employment, education, and in all other areas of the University. The University provides reasonable accommodations to qualified individuals with disabilities upon request.

This study was funded by the Maine State Legislature, and the University of Maine System.

A Center of the
School of Education and
Human Development

140 School Street, Gorham, ME 04038
(207) 780-5044; TTY (207) 780-5646
www.cepare.usm.maine.edu
A member of the University of Maine System

Table of Contents

Policymaker Summary ..... **i**

Study Purpose **1**

Background **1**

Methodology **3**

Findings **4**

Partnering with the Dana Center & the Conference Board of Mathematical Sciences 5

Promoting Individualized Student Learning in Math & Career Readiness 7

Clarifying Math Expectations & Reducing the Need for Remedial Coursework 8

Orchestrating Political & Organizational Shifts: Progress and Challenges 8

Organizational and Political Challenges Facing the State Universities and K-12 system 10

Avoiding Pitfalls of Tracking 11

Moving Forward: Establishing Organizational Ownership and Accountability for the Reforms 12

Conclusions and Policy Implications **12**

References **14**

Policymaker Summary

For this project, MEPRI researchers were asked to describe and summarize the "mathematics pathways" movement which is currently underway in the state of Maine, as well as in other states across the country. For the past several years, attention has turned toward reviewing and reframing the curricular pathways in math for students, particularly at the post-secondary level. Focus has shifted not only to math preparedness, but also to redefining the curricular pathways that lead to academic and career success. In higher education, the central principle involves redefining and reorganizing coursework around defined pathways, based on academic and career interests of students. While "traditional" math tracks would still exist in some subject areas, other subject areas, like social sciences, would lean more heavily upon statistics, for example. For K-12 institutions, the math pathways reforms have less clear implications. One key organization working in this area—both nationally and in Maine— is the Dana Center at the University of Texas at Austin. The Dana Center has been partnering with the Maine Community College System (MCCS) for several years now, and has supported their progress toward implementing math pathways reforms.

This study of the math pathways movement is designed as a mini-case study to document the status of the reform in progress. Data collection began in August, 2019, and concluded in December, 2019. Data collection primarily included interviews and document/resource collection and review. Findings review math pathways as a potential means of promoting individualized student learning and career readiness, of clarifying math expectations, and of reducing the need for remedial coursework at the post-secondary level. The successes of and challenges facing individual institutions—from MCCS, to the state universities, to K-12 institutions— are also reviewed. Other challenges, including mitigating issues with tracking and ownership of the reforms, are discussed.

This report concludes by recommending that policymakers consider the differences between the political and organizational structures in evaluating whether and how to incorporate math pathways at the K-12 level, the pressing need to navigate future post-secondary expectations for students in CTE programs, as well as a recommendation to support developing guidance structures for students.

Study Purpose

For this study, MEPRI researchers were asked to describe and summarize the "mathematics pathways" movement which is currently underway in the state of Maine, as well as in other states across the country. Researchers were primarily asked to review the status of the math pathways reform movement happening in Maine's community colleges. In addition, researchers were asked to discuss the implications for the state universities and K-12 schools, including the process and potential challenges for both systems, and how these reforms might ultimately impact their math course requirements and expectations.

Background

College Readiness & Remediation

For both K-12 and post-secondary institutions, college readiness and student enrollment in remedial coursework at the post-secondary level is an ongoing policy challenge. Research shows that students who enroll in remedial coursework face multiple challenges, including financial burdens, which often negatively impact persistence and graduation rates (Bettinger & Long, 2005; Levin & Calcagno, 2008). In fact, researchers have found that academic preparation is the single strongest predictor of college graduation (Attewell, Heil & Reisel, 2011).

Within the umbrella of issues related to college readiness and remediation, math plays a particularly significant role. Students are placed in math remediation more often than other types of developmental courses, which, in-and-of-itself, is a strong predictor of dropping out. Research indicates that students who take longer developmental (remedial) coursework in math have reduced chances to reach graduation (Xu and Dadgar, 2017). At the community college level, nationally, students are most frequently assigned to math remediation, which then impedes their efforts toward graduation and careers (Ganga, Mazariello, and Edgecombe, 2018).

Maine Context: pK-12 & Post-Secondary

Maine's K-12 and post-secondary institutions face challenges surrounding math preparation and persistence that mirror many of the national trends. In the K-12 system in Maine, math performance is intricately linked with student outcomes. According to a 2015 report from the Mitchell Institute, Maine high school graduation rates, college enrollment, and persistence are related to high school math performance. The report states, "students who meet or exceed the

state math and reading standards in 11th grade are much more likely to enroll in college than are those who do not meet the standards" (Mitchell Institute, 2015). This relationship between college enrollment and 11th grade performance targets is stronger with math than with reading. According to this report, 88% of students who exceeded and 79% of students who were proficient 11th grade standards in math were attending college in the fall. Comparatively, 48% of students who did not meet the math standards attended college the following fall (Mitchell Institute, 2015). Of those students who enrolled in college, nearly all of the students who exceeded the 11th grade math standards persisted to college graduation, while 73% of students who did not meet the math standard persisted.

The mathematics sequence at the high school level has also been reviewed, particularly with respect to college readiness. In 2014, MEPRI researchers specifically examined college readiness as related to mathematics (Silvernail et al., 2014). This report found, among other things, that the high school math pathway of Algebra I, Geometry, and Algebra II, as outlined by Common Core State Standards Initiative in 2012, did not guarantee preparation for college. The report states, "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" (Silvernail et al., 2014, p.3).

At the post-secondary level, prior research conducted by MEPRI on remediation rates showed that across Maine's community college system, as well as at the state universities, the rate of remediation in math was consistently higher than in English (Johnson, 2016). According to this report, between 2012 and 2015, "The proportion of students enrolling in remedial mathematics courses was higher than for English, ranging from 0% to 55% across colleges, and was 24% overall across both systems" (Johnson, 2016). This report also shows that there is a strong correlation between math remediation and remediation overall.

The Mathematics Pathways Movement

Given this context, for the past several years, attention has turned toward reviewing and reframing the curricular pathways in math for students. Focus has shifted not only to math preparedness, but also to redefining the curricular pathways that lead to post-secondary and career success. Scaffolding this reform movement, there has been recent interest at the federal-

level of education to push for more vocational training (Hackman, 2019). While the mathematics pathways reforms are not necessarily vocationally-oriented in theory, they align with a more career-focused mission in post-secondary learning.

This reform movement manifests in different ways at the post-secondary level and the K-12 level. At its core, the math pathways reform is primarily a post-secondary effort. In higher education, the central principle involves redefining and reorganizing coursework around defined pathways, based on academic and career interests of students. While "traditional" math tracks would still exist in some subject areas, other subject areas, like social sciences, would lean more heavily upon statistics, for example.

For K-12 institutions, the math pathways reforms have less clear implications. On the one hand, K-12 schools could potentially adopt math pathways that were aligned with new post-secondary paths in math. However, this would mean addressing issues of equity related to tracking, as will be discussed, as well as negotiating within standards and curricular requirements.

One key organization working in this area—both nationally and in Maine— is the Dana Center at the University of Texas at Austin. Their work is partly grounded in the premise that calculus, despite its customary inclusion in post-secondary program curricula, is not needed for success in many programs of study. The Dana Center notes that majority of programs at community colleges (80%) and four-year universities (72%) do not require calculus (Burdman, 2015). They also highlight research that suggests that the traditional calculus pathway is intended for individuals who are considering pursuing physical science, mathematics, biological science, computer science, engineering, business, or agriculture (Chen & Soldner, 2014). Currently, the Dana Center is working with multiple states throughout the country, and beginning to pilot supporting K-12 systems in aligning with the pathways in several metro areas.

Methodology

This study is designed as a mini-case study to document the status of a reform movement in progress. Data collection began in August, 2019, and concluded in December, 2019. Data collection primarily included interviews and document/resource collection and review.

For the primary the data collection process, multiple interviews were conducted with key stakeholders and informants in the State. These stakeholders were identified by their

involvement in the math pathways reform movement, beginning primarily with actors from the community colleges. Throughout the interview process, "snowball" sampling— in which researchers asked interviewees for recommendations of others potential interviewees (Merriam, 1998; Bernard, 2002)—was used to identify further stakeholders and informants. Stakeholders from each of the major institutions (K-12 system, community colleges, state universities, and other partners) were intentionally selected in order to represent diverse viewpoints in this reform. Interviews were primarily conducted over the phone or virtually, and from about 45 minutes to 1 hour each. These interviews were semi-structured, but were not recorded. During the interviews, detailed notes were taken, including direct quotes, where possible. Once completed interview notes were coded and mapped for themes.

In addition, documents—particularly presentation materials and curricular examples—were collected from stakeholders and organizations. These documents were analyzed for themes, and research foundations.

Major topics from the across interview and the document data were aligned to develop the outline for the major findings. Once identified, examples were drawn from the data to support the finding categories.

Findings

Based on our analysis, the findings for this report are organized into six major categories:

(1) a detailed description of the work of the Dana Center, which has been central to Maine's post-secondary math pathways reforms;
(2) math pathways as a means of promoting individualized student learning and career readiness;
(3) math pathways as a means of clarifying math expectations, and reducing the need for remedial coursework at the post-secondary level;
(4) the successes and challenges of orchestrating the political and organizational shifts necessary to implement math pathways;
(5) avoiding the pitfalls associated with tracking; and,
(6) the challenges of establishing ownership and accountability for the reform movement moving forward.

Partnering with the Dana Center & the Conference Board of Mathematical Sciences

Interviews indicate that fundamental to the math pathways reforms taking shape at the post-secondary level in Maine is the work of The Charles A. Dana Center [the Dana Center], which operates out of the University of Texas at Austin. The Dana Center has partnered with states around the country to implement math pathways reforms at the post-secondary level. In addition, the Dana Center has recently begun work with a few regions on bolstering high-school reform efforts in order to bolster "transitions" to the post-secondary environment.

The Dana Center's reform model has four central principles (Table 1).

Table 1. Four Central Principles of Reform, Taken from Dana Center Brochure
Institutions implement structural and policy changes quickly and at scale: 1. "All students, regardless of college readiness, enter directly into college mathematics pathways aligned to programs of study." 2. "Students complete their first college-level mathematics requirement in their first year of college."
Institutions and departments engage in a deliberate and thoughtful process of continuous improvement to ensure high-quality, effective instruction: 3. "Strategies to support students as learners are integrated into courses and are aligned across the institution." 4. "Instruction incorporates evidence-based curriculum and pedagogy"

These principles highlight the organization's emphasis on creating structural change at a large scale, and across institutions. Ultimately, the Dana Center "seeks to ensure that all students in higher education will be: (1) Prepared to use mathematical and quantitative reasoning skills in their careers and personal lives; (2) Enabled to make timely progress toward completion of a certificate or degree; and (3) Empowered as mathematical learners" (Math Pathways presentation @KVCC, October 2019).

Representatives of educational institutions in Maine have been working with the Dana Center on developing the math pathways for nearly two years now. According to interviews, initially, Southern Maine Community College (SMCC) partnered directly with the Dana Center, laying the groundwork for the institutional connections and the original reform efforts. Much of this work grew out of the Achieve the Dream (ATD) reform efforts at the community colleges.

More recently, the Dana Center has worked directly with the broader Maine Community College System (MCCS).

The Dana Center brings to these reform efforts a mathematics pathways model, called the Dana Center Mathematics Pathways (DCMP). This sequence of coursework includes specific curricular and pedagogical guidelines for which organization has been training and implementation support to post-secondary institutions since 2012. According to The Dana Center,

> The Dana Center Mathematics Pathways (DCMP) works at the national and state levels and with institutions to implement math pathways aligned with the DCMP model. We embrace work across higher education sectors to provide faculty, staff, administrators, and policy representatives with the resources, tools, and services necessary to implement high-quality mathematics pathways. Through coordinated effort across multiple levels of the system, we can drive systemic, sustainable change for our nation's students. (Dana Center Brochure, page 1)

The reach and experience of the Dana Center in the area of mathematics pathways reforms is widespread. Currently, the DCMP has "contributed to the implementation of mathematics pathways" in at least 25 states (Dana Center Brochure, p. 1).

In order to support the mathematics reform work, the Dana Center provides multiple types of services, including, but not limited to, professional learning opportunities for faculty, staff, and administrators, strategic supports in the form of "processes, toolkits, and facilitation to mobilize diverse stakeholders," consulting, and other "tools and resources" for implementation of the math pathways (Dana Center Brochure, page 2).

One such service is development and training in specific pathways coursework. For example:

> *Foundations of Mathematical Reasoning* (FMR) course is a semester-long quantitative literacy-based course that surveys a variety of mathematical topics needed to prepare students for college-level statistics, quantitative reasoning, or algebra-intensive courses. The course is organized around big mathematical and statistical ideas. The course helps students develop conceptual understanding and acquire multiple strategies for solving problems. FMR prepares students for

> success in future courses and helps them develop skills for the workplace and as productive citizens. (Dana Center website, 2019)

This course has been designed by the Dana Center to be one of the initial, core math classes in their pathway and provides a common curricular entry point for students in post-secondary schools.

Maine has also worked in collaboration with the The Conference Board of Mathematical Sciences (CBMS) in these efforts. The CBMS supports work around college mathematics pathways reforms, and 23 states (including Maine) are engaged in the CBMS High School to College Math Pathways project. This multi-state effort was "directed at bridging the gaps between high school and college mathematics." Several interviewees reported that, in recent years, there had been discussion at CBMS that "they had over-emphasized Algebra II" as a core hurdle to mathematics progression.

In May, 2019, the CBMS hosted their annual conference in Virginia in collaboration with the Dana Center and Achieve the Dream. Three representatives from Maine attended this conference. The relationship with the Dana Center and ATD seemingly hastened and reframed the reform efforts to pathways implementation for CBMS. In the opening remarks of this forum, the CEO of CBMS noted that the agenda for this annual convention was "different" noting: "We want something to happen, not just come together and learn, but we want outcomes-- systemic outcomes" (CBMS Forum, 2019).

Promoting Individualized Student Learning in Math & Career Readiness

Representatives from both K-12 and post-secondary educational institutions discussed the benefits of the work of redefining the math curricular pathways for post-secondary institutions. The primary benefit cited was supporting the individual interests and academic needs of students as they focus in on career and academic goals. For many of Maine's post-secondary institutions, as well as for organizations invested in career training, such as Educate Maine, this is commonly discussed as a motivation for pushing forward with math pathways reforms. Individualizing the math curricular coursework required for different post-secondary degrees—with an eye toward eventual career training— was commonly agreed upon as being beneficial. Many interviewees spoke about the need for certain students to focus on particular math skills rather than defaulting

toward taking more traditional advanced math coursework based on college algebra. For example, for students studying social sciences, statistics coursework would best support and align with their academic and career training. Ideally, in addition to providing academic- and career-focused training, students would be able to see the benefits of—and therefore feel more invested in—this type of math coursework. This would, ultimately, help with persistence and degree completion. Because these pathways connect mathematical reasoning to real-life examples and problems, the coursework in math creates student buy-in by being applicable to their academic and career goals.

In addition to supporting goals about individualized student learning and careers, several interviewees cited the changing nature of schooling at the post-secondary level in focusing more on specific career training needs rather than simply degree accrual.

Clarifying Math Expectations & Reducing the Need for Remedial Coursework

According to interviews, one part of having a clear set of expectations around math curricular requirements and pathways—particularly between the K-12 and post-secondary institutions—could help to mitigate the need for remediation. In theory, if K-12 institutions were able to align their instruction with math pathways established at post-secondary schools, or simply to have clear expectations about what would be expected of students in college, students would be prepared for the next step in the "pathway." As evidence of this potential, the Maine Community College System noted in their October 2019 presentation that, since implementing the math pathways, their enrollment in remediation has been reduced. Given the impact of remedial coursework on persistence and graduation, this is a significant pattern.

Orchestrating Political & Organizational Shifts: Progress and Challenges

There are many educational institutions and organizations involved in this reform effort—primarily the state universities, the community colleges, and the K-12 system. Each of these institutions is at various stages of implementation of the math pathways reforms. One of the major issues discussed by interviewees was the potential challenges (and benefits) of orchestrating this major political and organizational shift, as well as the progress that the community colleges have already made along this path.

Progress at the Maine Community College System

SMCC began to work with the Dana Center after partnering with several representatives from the Dana Center on Achieve the Dream (ATD) work. In May of 2018, SMCC hosted a two-day meeting with Dana Center representatives. The purpose of this meeting was primarily to provide overview and training about the Foundations of Mathematical Reasoning course to faculty.

During much of 2019, the community college system focused on implementing the math pathways reforms with the support of the Dana Center and CBMS, with the goal of sharing their work with the broader statewide community in the fall. At the beginning to October, representatives from the Dana Center met with representative in the state of Maine to outline "action steps."

At the end of October, 2019, the Maine Math Pathway Collaborative—made up of key players in the math pathways reforms in Maine— convened for a day-long meeting at Kennebec County Community College (KVCC). During this meeting, presentations were given by multiple stakeholders and institutional representatives, including MCCS, the state University system, Educate Maine, and the K-12 system. Several participants noted that there was uneven representation from stakeholders at this meeting. In particular, it was noted those colleges present were not representative of the entire spectrum of post-secondary universities. Neither was there consistent representation from K-12 school district administrators, beyond Maine Department of Education leaders. The presentations at this meeting reviewed a variety of issues, including reviewing the relevance of calculus and the variety of pathways.

MCCS highlighted the progress their organization had made to date on math pathways reforms, including, establishing four pathways as well as co-requisites courses. These four pathways include technical mathematics, quantitative reasoning, statistics, and college algebra. Student program areas are sorted into these four categories. For example, students studying building construction would follow the technical mathematics pathway. MCCS noted that the pathways work was progressing on all campuses, and that their "developmental enrolment [was] down" overall (Maine Math Pathways Collaborative presentation @ KVCC, October, 2019).

According to many stakeholders present at the October 2019 meeting, it was clear that the MCCS had made substantial progress in converting and aligning their math coursework across institutions—essentially completing the changeover in less than two years. One

participant noted s/he was "surprised by how far along they were" in the reform process. Others stated that the community college has done "significant work," and several people noted the enormity of the organizational, political, and curricular challenge of achieving them

Organizational and Political Challenges Facing the State Universities and K-12 system

In contrast, the work of the state university system had only just begun as of the fall 2019. Representatives of several state universities indicated that they would drawing on the work of MCCS as a model for how to begin to roll out the conversation in their universities. Discussions at the K-12 were only in their naissance—seemingly just beginning to understand the work happening at MCCS and still exploring whether, and how, it should impact their own math preparation.

Many interview participants noted the simple challenge of changing and aligning multiple institutions around this agenda. Currently, as noted above, the Maine Community College System has made a great deal of progress in moving forward the math pathways reforms. A representative at the state system noted that they are using the work done by the community colleges as a model, but are just beginning to digest that information. There was also discussion about the different political and organizational structures at state universities as compared with the community colleges. The state universities also serve a different population of students, generally speaking, than the community colleges, and even among themselves the seven institutions have distinct academic purposes and goals. Thus, while they can draw on the community colleges in executing their reform efforts, the state system will face unique challenges related to political and organizational structures. Several people in the state universities noted that they have only just started to examine what the community system did to implement these reforms.

For the K-12 system, there are completely different political, organizational, and curricular structures. The math pathways reforms at the post-secondary level have dramatic impacts on the math curriculum and pedagogy, but the learning expectations at the K-12 level are dictated by the Maine Learning Results standards. Thus, high schools have less flexibility to choose a more focused math curriculum depending on each student's future career goals. Amongst interviewees, there was a general perception that the K-12 system in Maine was not yet invested in the math pathways reforms. Part of this was, reportedly, due to the slow trajectory of

implementation overall, but also hesitancy on the part of some administrators to adopt or implement this reform.

Avoiding Pitfalls of Tracking

In interviews, questions were repeatedly raised about how to avoid pitfalls of tracking based on bias of institutions or uninformed decision-making on the part of students, particularly at the K-12 level.

Tracking has seen pushback at the K-12 level in recent years because of its tendency to be based on, and to replicate, societal biases. One major concern with respect to the math pathways reforms is that they are, inherently, based on creating tracks. While tracks can be positive reinforcements of student interests and expertise—particularly at the post-secondary level—as noted above, students have to be clear, active agents and advocates for their own educational and career interests, and, in addition, institutions have to avoid funneling students toward certain tracks based on bias. Interviewees for this research agreed that this was a major challenge, particularly at the K-12 level where students are less likely to have specific academic and career interests, and leaving pathways decision-making up to the high schools has the potential to fall to stereotyping students at a young age.

Even at the post-secondary level, tracking was a concern. Two ways to mitigate the tracking problems were discussed. Participants noted that the pathways need to be designed in a manner that avoids rigidity, allowing for fluid movement between academic interest areas, should a student decide to switch their study or career path. Creating a curricular pathway that is a track that simultaneously allows for flexibility is a significant challenge. The Dana Center has discussed and outlined what a curricular model for this would look like. Implementation and application at the educational institutions remains a question.

In addition, it was noted by multiple interviewees that guidance counselors would need to play a significant role at both the K-12 and post-secondary levels to ensure that students are making effective educational choices that starts them on a math pathway. Currently, The Dana Center does not invest in guidance counselor training to support the math pathways reforms, but relies on the individual institutions to bolster guidance practices on their own.

Moving Forward: Establishing Organizational Ownership and Accountability for the Reforms

Finally, interviews indicate that at the end of the October 2019 meeting, there was a sense of the overall organizational challenge of deciding who takes charge of the process moving forward, and at which institutions. Questions were raised about next steps, as well as accountability and timeline. Many interviewees felt that this process was not yet clear. This is to be expected given the relatively early stage of this effort.

Conclusions and Policy Implications

Based on the findings, this report outlines three key conclusions for policymakers:

(1) The distinction between K-12 and post-secondary roles in the math pathways reforms;
(2) Implications for CTE institutions; and,
(3) The need to invest in guidance/ support resources for both post-secondary and K-12 institutions.

K-12 versus Post-Secondary Involvement in Math Pathways Reforms

The findings of this study show that there is a clear distinction between the organizational, curricular, and political shift that would need to happen at the K-12 level, versus the post-secondary level, in order to begin to implement this change in math. At the moment, in Maine, K-12 representatives are observant, and engaged in the discussions, but seemingly not yet decided about whether to adopt or institute structural reforms. Part of the reason for this hesitation may be rooted in concerns about equity and tracking, as noted above. In addition, the K-12 system's curriculum is dictated by standards, which shapes any reform agenda. Thus, at the moment, the math pathways reform is primarily a post-secondary movement. The Dana Center noted that their organization is currently, actively supporting a few metro areas around the country in moving their K-12 systems towards pathways in math, but that was in a pilot stage.

For the K-12 system, at this point it is necessary to make sure that public school district leaders are aware of the changes occurring in math at the post-secondary level, and understand what students will need in their math education leading up to their entrance onto those tracks in college. Alignment with curricular expectations, such as having an understanding about the Foundations of Math course or the core pathways, would be beneficial for all teachers and administrators in K-12 to know.

Implications for CTE Programs

The math pathways movement at MCCS has more immediate relevance to those CTE programs that directly align to post-secondary preparation. Several CTE tracks are intended to set students up for a smooth transition to a MCCS credentialing program, and some CTEs even have articulation agreements that allow their high school students to earn community college credits for their CTE work. This creates a more pressing need to navigate the differences between high school graduation requirements and the future post-secondary expectations for students in those CTE programs.

Guidance/ Support Resources for Post-Secondary (and K-12) Institutions

In order to effectively guide students onto, through, and between the pathways they develop, strong systems of guidance and support are going to be needed at all institutional levels. While this could potentially look like formal guidance counselor roles, it should also manifest in more informal faculty and administrator support and knowledge of the math pathways. At the post-secondary institutions, faculty need to be clear not only on the math pathways related to their own department, but also the other pathways, in order to minimize rigidity of the system. Formal guidance—specifically around math— at the post-secondary level would be beneficial to get students oriented upon enrolling, as well as periodically throughout a student's tenure. Regular evaluations of student need would help prepare students for the pathway ahead as well as their academic and career progression.

References

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

Bernard, H.R. (2002). *Research methods in anthropology: Qualitative and quantitative approaches (3rd edition).* New York: Alta Mira Press.

Bettinger, Eric and Long, B. T. (2005). Remediation at the Community College: Student Participation and Outcomes. *New Directions for Community Colleges*.

Burdman, P. (2015). *Degrees of Freedom: Diversifying Math Requirements for College Readiness and Graduation.* Oakland, CA: LearningWorks.

CBMS Forum (2019). Retrieved from: https://www youtube com/watch?v=QzrHSD9QFg8&feature=youtu be)

Chen, X., Soldner, M. (2013). *STEM attrition: College students' paths into and out of STEM fields (2014-001).* Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Dana Center website (https://www.utdanacenter.org/our-work/higher-education/higher-education-curricular-resources/foundations-mathematical-reasoning).

Ganga, E., Mazzariello, A., & Edgecombe, N. (2018). *Developmental education: An introduction for policymakers*. Denver, CO: Education Commission of the States, Center for the Analysis of Postsecondary Research.

Hackman, M. (2019). Education Budget Proposal Highlights Vouchers, Vocational Training. Wall Street Journal. Retrieved from: https://www wsj com/articles/education-budget-proposal-highlights-vouchers-vocational-training-11552326487

Johnson, A. (2016). *Remedial course enrollments and student outcomes in Maine's public higher education institutions.* University of Southern Maine: Center for Education Policy, Applied Research, & Evaluation. Retrieved from https://usm.maine.edu/sites/default/files/cepare/Remedial_Course_Enrollments_Student_Outcomes_Maine_Higher_Ed pdf

Levin, H. & Calcagno, J.C. (2008). Remediation in the Community College: An Evaluator's Perspective. *Community College Review*, 35(3), 181-207.

Merriam, S. (1998). Qualitative research and case study applications in education. San Francisco: Josey-Bass Publishers.

Mitchell Institute (2015). *Maine High School Graduates: Trends in College-Going, Persistence, and Completion.* Retrieved from: https://mitchellinstitute.org/wp-content/uploads/2014/01/MaineCollegeGoing2015.pdf

Silvernail, D. Batista, I., Sloan, J., Stump, E., Johnson, A. (2014). *Pathways to Mathematics College Readiness in Maine*. University of Southern Maine: Maine Education Policy Research Institute (MEPRI).

Xu, D. and Dadgar, M. (2017). How Effective Are Community College Remedial Math Courses for Students With the Lowest Math Skills?, *Community College Review,* 46(1) 62–81. https://doi.org/10.1177/0091552117743789