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Mathematics Pathways to Completion

Setting the Conditions for Statewide Reform in Higher Education

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Mathematics pathways are a promising approach for improving student outcomes, but if implementation happens one college at a time and without statewide policy support, the potential for scaling is diminished.

Introduction

Higher education is in the midst of an unprecedented wave of reform aimed at increasing student success. Small-scale efforts have helped to generate a growing evidence base for reforms but have failed to "move the needle" on broad measures of student success such as institutional or statewide rates of credential completion. In response, higher education systems have launched large-scale reform efforts (see, e.g., Denley, 2017; Kelchen, 2017; Kalamkarian, Raufman, & Edgecombe, 2015) aimed at maximizing individual impacts (i.e., producing profound effects on students' educational experiences and outcomes) that are implemented broadly and thus involve large numbers of students within and across institutions (Coburn, 2003). These large-scale reform efforts, which require substantial planning, coordination, and cooperation, likely represent higher education's most promising path to better student outcomes (Handel & Williams, 2012; Moore & Shulock, 2014).

An example of this scaling work is happening in postsecondary mathematics. Mathematics requirements are known to be a significant barrier to student progression in higher education; this is particularly true for the 59 percent of public two-year college students and 33 percent of public four-year college students who are enrolled in prerequisite, non-college-credit developmental mathematics courses (Chen, 2016). Research suggests that developmental and introductory mathematics programs have been obstacles to student success for multiple reasons, including lengthy course sequences and the mismatch of course content with the mathematical skill demands of students' degree programs and careers (Dunbar, 2006; Xu & Dadgar, 2017).

The *mathematics pathways* approach is a promising strategy to address these challenges. At institutions offering mathematics pathways, students take an introductory college-level mathematics course that is well-matched with their major or program of study. The goal is to align students' mathematics coursework with their academic and career needs, redirecting non-STEM students from lengthy algebraic-intensive course sequences to alternative college-level courses focused on statistics or quantitative reasoning. Importantly, students referred to developmental mathematics take preparatory coursework that is aligned to their particular introductory college-level mathematics course, often using an accelerated approach such as a corequisite model. Research has shown that the implementation of mathematics pathways increases the rate at which students earn college-level mathematics credits—an important completion milestone—and improves student retention and other long-term outcomes (Offenstein, Moore & Shulock, 2010; Hayward & Willett, 2014; Hoang, Huang, Sulcer & Yesilyurt, 2017; Logue, Watanabe-Rose & Douglas, 2016; Rutschow, Diamond, & Serna-Wallender, 2017; Rutschow, 2018).

Implementing mathematics pathways affects what is taught in the classroom. This means that within an institution, there is a need for deep faculty engagement in developing learning outcomes, curricula, and pedagogical approaches to support student success in new mathematics courses. At the same time, other stakeholders across multiple levels of the higher education ecosystem (e.g., state policymakers, higher education system

representatives, institutional administrators, and student services professionals) also play a critical role in ensuring that students receive high quality advising about mathematics pathway options, and that mathematics courses align to programs of study and articulate across transfer partners. If implementation of mathematics pathways happens institution-by-institution and lacks policy-enabling conditions to support transfer and program applicability of mathematics courses, it creates complications for scaling (Cullinane et al., 2014).

The Charles A. Dana Center at the University of Texas at Austin, the developer of the Dana Center Mathematics Pathways (DCMP) model, recognizes this challenge and has initiated the Mathematics Pathways to Completion (MPC) project to support each of six states in developing a broad statewide vision for mathematics pathways and a plan for institutional implementation of the DCMP model over three years. The Community College Research Center (CCRC) is serving as the project evaluator. This report describes the structure of the MPC project and the supports that the Dana Center is offering to participating states.[1] In addition, drawing on 33 semi-structured interviews with mathematics faculty, state-level leaders, and technical assistance providers across the six states, this report explores the question: What state-level structures, conditions, and processes facilitate statewide implementation of mathematics pathways?

The Dana Center Mathematics Pathways to Completion Project

The Dana Center Mathematics Pathways initiative began in 2012, in collaboration with the Texas Association of Community Colleges, to reform developmental and college-level mathematics courses in Texas higher education institutions. From this work in Texas, the Dana Center developed a theory of scaling to articulate a vision of "coordinated action across levels of the higher education ecosystem" (i.e., at the national, state, institutional, and classroom levels) (Cullinane et al., 2014). Specifically, the Dana Center called for an approach that tries to avoid both the pitfalls of top-down mandates that misunderstand the classroom and institutional conditions of implementation and the limitations of bottom-up initiatives that fail to take root and expand (e.g., Quint et al., 2011; Shaw & Heller, 2007).

The Dana Center launched the MPC project in 2015 in partnership with five states—Arkansas, Michigan, Missouri, Oklahoma, and Washington. The work supports two- and four-year public higher education institutions in implementing and scaling multiple, transferable mathematics pathways that enable students to complete a college-level mathematics requirement aligned to their program of study within one year, regardless of their initial level of preparation. Massachusetts joined the project as a sixth partner in 2016.

The Dana Center's theory of scaling mathematics pathways identifies four phases of activity; however, due to time constraints of a three-year project, the MPC was designed to unfold in just three phases: (1) Building urgency and intrinsic motivation by empowering mathematics leaders, (2) enabling scale by creating policy and practice conditions for

system-wide implementation, and (3) enacting DCMP principles at institutions.[2] This report focuses on state-level activities in Phases 1 and 2. Phase 3, which emphasizes institution-level implementation, is currently underway in MPC states.

During Phase 1, the Dana Center supported each state in building urgency and empowering mathematics leaders by convening mathematics faculty from two- and four-year institutions in a state-level task force to establish a vision of mathematics pathways. Some states also included other stakeholders, such as K-12 system representatives and institutional administrators, but mathematics faculty were positioned as the leaders and experts in each task force's Phase 1 work. Some task forces included representation from every public institution; others did not include every institution but ensured that all systems and sectors (i.e., research universities, comprehensive four-year institutions, and two-year colleges) were represented. The task force in each state was led by a leadership team consisting of at least two mathematics faculty co-chairs—one from a two-year college and one from a four-year institution—and at least one system-level representative serving as the facilitator.

As part of its work in Phase 1, each faculty-led task force drafted a set of recommendations related to the vision of mathematics pathways implementation in its state.[3] Recommendations varied across states in number and specificity but commonly addressed which pathways were to be offered and key processes for implementation (e.g., student assessment and placement, establishment or enhancement of articulation agreements, faculty development). Each task force led a process by which recommendations were vetted by a variety of state- and institution-level stakeholders. Dana Center staff also provided formative feedback. Upon revision, each state's task force recommendations were published on the DCMP website and disseminated within each state. In their final form, each task force published between three and eight recommendations. Sample recommendations include the following:

The MPC project supports implementing and scaling multiple, transferable mathematics pathways that enable students to complete a college-level mathematics requirement aligned to their program within one year.

- Academic disciplines identify math competencies needed for specific programs of study and use competencies to recommend a common transferable math course requirement for each program of study (statistics, college algebra, quantitative reasoning, calculus).[4]
- Institutions should align the process of placing students in credit-bearing courses with alternative pathway courses.[5]
- Provide postsecondary mathematics faculty members with professional development related to teaching in pathways.[6]

With mathematics leaders from across each state engaged in the MPC project and with a vision of mathematics pathways established for each state via the recommendations, Phase 2 focused on enabling scale by creating the policy and practice conditions for statewide implementation. State-level activities during this phase included, but were not limited to, forming working groups to address issues related to transfer and applicability, forming working groups to develop student learning outcomes for mathematics pathways courses, surveying non-mathematics faculty on mathematics competency needs within programs of

study, and coordinating activities with other state-level initiatives focused on developmental mathematics, including corequisite and placement reforms. Each task force also created plans to scale mathematics pathways across all public higher education institutions in the state, which included defining what constitutes full-scale adoption (e.g., the minimum percentage of students to participate in mathematics pathways), associated student success measures and goals, and three-year milestones for institutional implementation (e.g., the minimum number of pathways to be implemented at each institution and the number of institutions to participate each year).

The task force leadership teams for each state also conducted outreach during Phase 2 to identify institutions willing to be among a first cohort of pathways implementers. Institutions were asked to provide a commitment, sometimes in the form of a signed memorandum of understanding, to implement mathematics pathways in fall 2018 according to task force-established parameters.

Across both Phases 1 and 2, the Dana Center provided a framework for states that included objectives, deliverables, suggested timelines, and processes for convening stakeholders and maintaining momentum toward project goals. While the activities and products in the framework were described in detail, they were also made intentionally flexible so that each task force could adapt them to its own context. Additionally, each state was provided a consultant to guide and support the task force in its efforts. In Phase 2, Dana Center staff held regular check-in calls with the leadership team in each state and provided workshops on a range of topics, including designing and implementing mathematics pathways and designing corequisite courses. They also provided a set of resources on the Dana Center website[7] that offered guidance to states and institutions as they planned, implemented, and enacted their task force recommendations. Phase 3 (which, as noted earlier, is not described in this report) began in fall 2017 with a focus on supporting institutional teams charged with implementing mathematics pathways at their institutions (Cook & Ortiz, in press).

MPC framework activities were made intentionally flexible so that each task force could adapt them to its own context.

Critical Dimensions of Scaling Mathematics Pathways Statewide

In this section, we describe five critical dimensions for working toward statewide implementation of mathematics pathways in Phases 1 and 2 that emerged from our data analysis. For each dimension, we describe the related challenges and provide specific examples of how the task forces addressed those challenges with the support of the Dana Center.

Five Critical Dimensions of Scaling Mathematics Pathways Statewide

1. Attention to transferability and applicability
2. Leadership from across two- and four-year sectors
3. Strong mechanisms for gaining consensus on student learning outcomes
4. Engagement of non-mathematics stakeholders
5. Coordination with related initiatives

1. Statewide scaling of mathematics pathways requires attention to both the transferability and applicability of pathways courses.

A major barrier to scaling mathematics pathways is uncertainty about the transferability and program applicability of mathematics pathways courses. As many as 80 percent of incoming community college students indicate an intention to transfer to earn a bachelor's degree; yet, in practice, about 25 percent of two-year students transfer to four-year institutions (Jenkins & Fink, 2015). Those who do transfer often experience inefficiencies including loss of credits and the accumulation of excess credits (Government Accountability Office, 2017; Monaghan & Attewell, 2015; Fink et al., 2018).

Transferability refers to whether a receiving institution will accept a given course for credit. *Applicability* refers to whether a course will be accepted for credit within a program of study. Transfer partner institutions may have an agreement about courses that fulfill a set of general education requirements, but these courses may or may not be applied to the variety of programs of study within the receiving institution. If a student takes a mathematics course at the sending institution that is not applicable to their program of study at the receiving institution, then the student will need to take the correct course, thus potentially extending time to degree and accumulating excess credits. Misaligned prerequisite requirements also present challenges. For example, intermediate algebra (often a developmental-level course) may be required even if a transfer student has college-level credit for a pathways course such as statistics or quantitative reasoning.[8] Institutions, particularly community colleges, are reluctant to expand offerings of alternative introductory college-level mathematics courses until they have assurances that the courses will be accepted and applicable at their transfer partner institutions. As a task force member recounted in an interview:[9]

> *Quantitative reasoning is actually a transferable course in our course transfer system. But the problem is, nobody knows for sure what majors [it] counts towards and what majors it doesn't. So there's just this hesitancy at the two-year level in particular to recommend that students take quantitative reasoning.*

To surface and attend to these challenges, the Dana Center provided guidance and resources for each MPC state to form a working group to identify and address issues related to transfer and applicability. Some of the main goals of these working groups were to understand: (1) the existing legislation and policies that impact transfer; (2) the mechanisms to improve alignment, articulation, and applicability; and (3) the student transfer patterns in the state. With the support of Dana Center policy staff, some transfer working groups also explored

student outcomes associated with transfer to find out whether students lose credits or earn unnecessary credits due to misalignment across institutions.[10] One task force member we interviewed identified the importance of grounding mathematics pathways planning decisions in data: "What I keep observing is [that faculty] are most concerned with transfer with the prestigious institution in their area even if the majority of their students do not transfer [there]." Better understanding transfer patterns can inform course offerings at the sending institution and entry-level requirements at the receiving institution.

Some task forces were able to leverage existing infrastructure to facilitate changes to transfer policy. For example, Oklahoma convenes faculty each year to update the state's course equivalency tables,[11] and the Oklahoma task force used this venue to discuss mathematics pathways course objectives and to ensure that the pathways courses would be transferable. In cases where statewide agreement on transfer or applicability was not feasible, states also explored the possibility of using regional agreements among clusters of schools with frequent transfers. However, many of these potential changes to general transfer policy do not necessarily ensure applicability to programs of study. To discuss program applicability, states needed to engage faculty from other disciplines; the ways in which they did so are discussed below.

2. State-level change is enabled by engagement and leadership from across two-year and four-year sectors.

Equal engagement and leadership from two- and four-year sectors emerged as a critical component to moving toward full-scale implementation. In states with a centralized lead agency (i.e., a consolidated department of higher education), equal engagement across sectors was more routine. However, in many contexts, regardless of state infrastructure, the two-year sector was perceived to be more invested in mathematics pathways reform. The benefits for two-year colleges, many of which have large numbers of students who never complete their developmental mathematics sequences or pass college-level mathematics, were often clear. In some states, the project facilitator was affiliated with two-year colleges, which meant that, as one stakeholder put it, "the center of gravity" was situated in the two-year sector. In one context, a stakeholder observed that "the documents the [task force leadership] tends to produce tend to sound like they are aimed at community colleges." Thus an imbalance of leadership may create a cycle in which four-year institutions continue to be perceived as peripheral participants.

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Stakeholders reported that selective institutions were less likely to see the urgency of mathematics reform, particularly in research universities where faculty attention is more likely to be focused on scholarship. Respondents also reported that a fear of a loss of rigor was a particular concern at some four-year institutions. However, stakeholders did articulate a rationale for mathematics pathways specific to four-year institutions. One four-year representative explained:

> *We have statistics that [show that] students who pass remediation and come into our college algebra [course] fail at over 70 percent. Remediation is supposed to make them ready, but remediation was not working in this state.*

For four-year institutions that rely on a well-qualified pool of transfer students, mathematics pathways reform is appealing in that it is expected to enhance the preparation of incoming students. That is in part because in addition to directing non-STEM students into mathematics courses aligned with their programs of study, states are working on enhancing the mathematics pathway to and through college algebra to better meet the needs of STEM students. Task force members reported that they were seeking ways to communicate about mathematics pathways that specifically address the priorities and concerns of four-year institutions.

The Dana Center asked MPC states to create a communication plan to make the case for mathematics pathways and engage both two- and four-year constituents, a process which was underway during our data collection. More broadly, stakeholders reported the need for strategic communication about the goal of mathematics pathways. One respondent talked about a shift in messaging:

> *It has always been, "They can't pass college algebra, therefore you need something else." And that's an insinuation of dumbing it down. [Faculty] want students to come out with critical thinking skills. It's like the number one thing that industry will say. You've got to change the message.*

In addition to considering the messaging itself, some states were able to deploy influential messengers. For example, in one state two research university faculty members, each with statewide and national leadership experience on a variety of mathematics reform issues, were members of the task force leadership team. Their engagement as "champions" offered several advantages: It lent credibility to the effort; it assuaged some fears among two-year colleges about the viability of new courses for transfer; and it ensured that the needs of four-year institutions were heard.

3. In order to move toward scaling, states must devise robust mechanisms for gaining consensus on student learning outcomes of multiple mathematics pathways.

Stake task forces were charged with identifying and developing common student learning outcomes for introductory college-level mathematics courses (e.g., college algebra, quantitative reasoning, introduction to statistics), in part to ensure course transferability and applicability. Interviewees in each state articulated a general sense of agreement that mathematics pathways were a promising mechanism for increasing student persistence and success in mathematics. However, despite this broad buy-in for the notion of reform, generating consensus on which pathways to offer and what the student learning outcomes should be within those pathways presented significant challenges. Many institutions already offered versions of proposed mathematics pathways courses and thus had their own assumptions about the appropriate course objectives and prerequisite requirements. For example, stakeholders reported wide inter- and intra-institutional variation in the expectations and content of mathematics for liberal arts, a course that was often slated to fulfill the requirements of quantitative reasoning. Another common

Despite broad buy-in for the notion of reform, generating consensus on student learning outcomes presented significant challenges.

contentious issue was eliminating intermediate algebra and/or college algebra as a prerequisite for statistics.

In order to broker agreement on content and prerequisites, the Dana Center recommended that each task force convene a working group for each pathway comprised of faculty representatives from both two- and four-year institutions charged with developing common student learning outcomes and making other recommendations about curriculum and pedagogy. The Dana Center published a document[12] describing a process for establishing student learning outcomes, which included recommendations under a number of stages, including: "Conduct Research and Gather Input" and "Engage Faculty and Departments." However, working groups in some states reported wanting more guidance and resources related to developing student learning outcomes for specific mathematics pathways. One interviewee reported that even after several working group meetings, they still lacked consensus on the purpose and goals of quantitative reasoning:

> *I don't think there's a clear vision of what quantitative reasoning really is statewide. We need to meet more and we need the time to do it.... When you get more than six or seven people in a room, it's just difficult.*

In response to specific challenges related to statistics, the Dana Center offered on-demand workshops focused on designing the statistics pathway to support states in navigating these decisions about content. A similar workshop on designing a pathway to calculus was also made available. Overall, stakeholders' perspectives suggest that the states must allocate ample time and resources—including guidance on process—to support faculty to explore and generate consensus on learning outcomes. As described below, non-mathematics disciplinary faculty have the potential to be important contributors to this work.

4. State-level scaling work is enabled by the engagement of a diverse array of non-mathematics stakeholders, including institutional administrators, state-level policymakers, advisors, and faculty from multiple disciplines.

The Dana Center intended for each state task force to include mathematics faculty and state-level leaders. The engagement of mathematics faculty was critical to lending legitimacy to the mathematics pathways reform as well as to determining the content and objectives for each pathway; state-level leaders are essential to mapping the larger policy and reform context. However, this project demonstrates that other non-mathematics stakeholders, including institutional administrators, faculty from other disciplines, and advisors have an important role to play, and their early engagement in the process can lay the groundwork for setting the conditions for scaling. For example, non-mathematics faculty at both two- and four-year institutions are responsible for establishing the applicability of mathematics courses to programs. As one stakeholder explained, "We have to be very intentional about including faculty in [other] departments and making sure that we are addressing the issues that they have concerns about, for example, rigor." Stakeholders reported numerous anecdotes about non-mathematics faculty's preference for the algebra sequence.

> *[The division chair] insisted that this astronomy course has a prerequisite of intermediate algebra. In [intermediate algebra] we factor, we do the*

> *quadratic formula, we solve radical equations, we solve rational equations. And I asked, "Does that help a student be successful in your astronomy course?" He says, "I want them to be able to manipulate a simple equation." Well, we teach that in pre-algebra, actually.*

Through the engagement of faculty from other disciplines, mathematics pathways advocates can increase knowledge and awareness about pathways courses and dispel misconceptions.

A second key stakeholder group is comprised of advisors who must be well informed of changes to mathematics requirements within and across institutions to ensure that students enroll in an appropriate mathematics courses. Stakeholders reported that advisors were understandably reluctant to advise students into alternative mathematics pathways if program applicability or transferability was not clear. A task force member explained: "[Advisors] want something in writing from somebody in authority that tells them this is what's going on and this is what each of the institutions are requiring." Many colleges in the participating states offered alternative mathematics pathways courses, but enrollment was low: "They all have the courses on the books, but a majority of students are signed up for college algebra."

Advisors must be well informed of changes to mathematics requirements within and across institutions to ensure that students enroll in an appropriate mathematics course.

In conjunction with fostering engagement among a broad array of stakeholders to aid in decision-making, respondents again noted the importance of strategic communication about mathematics pathways within institutions. One task force member described challenges in ensuring that institutional representatives were well-informed about ongoing pathways work:

> *I think there is an assumption that you got 15 or so people in this room and that we're actually taking what happens in this room back to our institutions. And I discovered that [task force members are] not even communicating with fellow math faculty, let alone the college as a whole.*

Thus, task force representatives could have benefited from guidance on sharing planning processes and other developments to foster understanding and buy-in among their colleagues.

In response to these challenges, the communication plan that the Dana Center asked each task force to create included considerations for strategic outreach to a diverse set of stakeholders identified as crucial to the eventual implementation and success of mathematics pathways. Task forces in some states were exploring ways to involve non-mathematics faculty for the purposes of both understanding their program needs and to make the case for alternative pathways. In Arkansas, task force members devised a survey for non-mathematics faculty in transfer programs at all the institutions in their state. The survey asked about mathematics competencies needed in each particular program rather than for a preferred mathematics course.[13] This was intended to mitigate faculty biases in favor of algebra.

> *And so we are hoping consensus emerges around specific majors. And then we are going to make a recommendation that for that particular program of study or major, [the requirement] should be quantitative reasoning, statistics, or college algebra.*

Other states had plans to convene groups of non-mathematics faculty by discipline to have them learn about pathways courses and to potentially reach cross-institutional consensus on the best course(s) for their programs.

States were also looking for opportunities to engage advisors more directly. One goal Washington was working toward was the development of easy-to-read marketing and informational materials to describe the pathways and their articulated programs. In Phase 3, the Dana Center is offering advising workshops designed for teams of advisors and institutional stakeholders with a focus on ensuring that advisors are well informed and well equipped to assist students in making the right mathematics pathway choice. At the time of our data collection, several states were also planning to engage advisors' professional associations for the purpose of increasing knowledge about pathways.

5. Planning for mathematics pathways implementation benefits from close coordination with ongoing reforms to developmental mathematics, comprehensive "guided pathways" reforms, and other similar initiatives.

All states participating in the MPC project have ongoing reform efforts that they have connected to the effort to implement and scale mathematics pathways. These include efforts to improve alignment between K-12 and postsecondary mathematics, efforts to improve the state's transfer infrastructure, and efforts to improve developmental mathematics (e.g., by introducing multiple measures for placement and corequisite remediation courses). Likewise, community colleges in each state are embarking on "guided pathways" reforms, often with guidance and support at the state level. Colleges participating in guided pathways reforms are, among other things, working to create program maps (complementing mathematics pathways efforts) that define and explain course sequences and co-curricular requirements that lead to a credential in a specified program of study and that are transferable at four-year institutions.

For on-the-ground stakeholders, there was often uncertainty about moving ahead on multiple, separately managed, overlapping reforms.

These initiatives were typically launched at different times and managed by different organizations, often with different messaging. One stakeholder in a state with a well-established guided pathways effort described institution-level reactions to mathematics pathways:

> *The question for us is, "How exactly does this connect to the guided pathways initiative?"—which is sort of the larger overarching system initiative. So I think there is a real legitimate question to say, "Now we come in there talking about math pathways. What is the connection?"*

For on-the-ground stakeholders, there was often uncertainty about navigating the logistics of moving ahead on multiple, separately managed, overlapping reforms. Some expressed concerns about redundancy of efforts and missed opportunities for coordination. For example, as guided pathways colleges create program maps, they are presented with an opportunity to assess the most appropriate college-level mathematics course for each program. Without strong coordination, programs may select college algebra, further

codifying the algebraic-intensive pathway as a default. Likewise, reformers must be attentive to how redesigned developmental pathways into college-level mathematics might impact ongoing efforts to implement corequisite remediation or changes to developmental placement practices.

With support from the Dana Center, task force leaders were at the time of our interviews striving to increase communication across these initiatives; this was perceived to offer opportunities for efficiencies and momentum. For example, several states ensured cross-attendance at guided pathways, corequisite, transfer, and mathematics pathways task force meetings. In one instance, a co-chair of a mathematics pathways task force leadership team served on the leadership team for corequisite remediation and vice versa. A task force member explained another approach: "So we're thinking of [bringing] the guided pathways colleges together in a focused discussion: 'What are you doing right now to think about how math fits into your meta-majors [broad subject areas that entering students choose from before selecting programs of study]?'" Additionally, during Phase 3 of the project, the Dana Center is offering corequisite course design workshops for institutional stakeholders, which in some contexts serve as a bridge between mathematics pathways and other developmental education reform initiatives.

Conclusion

Mathematics Pathways to Completion is designed to draw on the strengths of a faculty-led or bottom-up approach while also enabling the policy conditions necessary for widespread change through a top-down approach (Cook & Ortiz, in press). Top-down approaches to change in higher education can be effective in achieving scale (e.g., Turk, Nellum, & Soares, 2015; Hu et al., 2016; Daugherty et al., 2018); however, they are vulnerable to weak implementation, particularly when they fail to be responsive to the realities and needs (including resource needs) of practitioners charged with carrying out the associated reform. By contrast, locally initiated efforts often remain on the margins, serving small numbers of students.

There are few documented examples of statewide higher education reforms that include participation of both two- and four-year sectors. This is not surprising given the relatively limited cross-sector collaboration that occurs in most contexts (Logue, 2017; Moore & Shulock, 2014). Yet cross-sector collaboration is essential for scaling reforms with substantial implications for student transfer, including but not limited to mathematics pathways. Over one third of students transfer between institutions, suggesting a highly mobile postsecondary student population; and the vast majority of students in public sector institutions who do switch colleges transfer within their states (Shapiro et al., 2018). Given the significant transfer inefficiencies that now exist, understanding processes by which reformers can facilitate large-scale cross-sector

Cross-sector collaboration is essential for scaling reforms with substantial implications for student transfer, including but not limited to mathematics pathways.

change to facilitate students' postsecondary education goals is essential to improving student outcomes.

Data collected for this report show how six states, in collaboration with the Dana Center, were coordinating action across higher education faculty, institutional administrators, and policymakers for the purposes of enacting top-down/bottom-up statewide reform. Our analysis thus far illuminates five critical dimensions of this work, including emphasis on (1) transferability and program applicability of courses, (2) leadership and buy-in across two-year and four-year sectors, (3) consensus-gaining mechanisms in establishing student learning outcomes (4) engagement of non-mathematics stakeholders, and (5) coordination with other related initiatives. Reform efforts along these dimensions were facilitated in each state by the creation of a mathematics pathways task force with broad institutional representation, a task force leadership team comprised of a two- and four-year mathematics faculty member as well as a state higher education leader, and working groups focused on project subcomponents (transfer concerns and student learning outcomes). The Dana Center provided guidance around the formation and charge of these groups, suggested timelines, and offered workshops and on-demand support for particularly challenging issues that emerged.

Prominent challenges included negotiating course applicability at the program-level, communicating the value of mathematics pathways work within the four-year sector, devising ways to engage non-mathematics faculty, and coming to statewide consensus on student learning outcomes. Stalled momentum sometimes occurred in striving to meet these challenges, which is unsurprising given the scope and complexity of the project and the number of stakeholders involved in each state. Monitoring progress, troubleshooting challenges, and brainstorming approaches to jumpstarting momentum were important features of the Dana Center's role in this project. With support, task force leaders undertook strategies to navigate these challenges, including the leveraging of existing infrastructure (such as transfer committees, professional associations of institutional administrators and advisors, and other ongoing reform initiatives) for consensus building and decision making and the identification of skillful leaders and credible mathematics pathways champions.

The MPC states are currently in Phase 3 of the project, which shifts focus from state-level activity to institution-level implementation. Task forces are charged with supporting and monitoring individual institutions as these colleges and universities make structural and policy changes to align with task force recommendations and other parameters for implementation established in Phase 2. The Dana Center is supporting the state task forces and institutional implementation teams as they engage in a variety of activities including aligning mathematics courses to programs of study, designing and implementing acceleration approaches, enhancing advising and student supports, modifying program requirements, and increasing the numbers of students enrolled in recommended mathematics courses aligned to programs of study. At the same time, many Phase 2 tasks related to transfer and program applicability are ongoing. A future report from CCRC will describe these activities and explore how implementation of mathematics pathways is unfolding at two- and four-year institutions in these six MPC states.

Endnotes

1. A final report on the MPC project will be published in 2019.
2. See Cook & Ortiz (in press) for a detailed description of the Dana Center's theory of scaling, the phases, and associated Dana Center-led supports and activities.
3. Massachusetts did not complete its task force recommendations report until January 2018, as its work began in fall 2016.
4. An Arkansas state task force recommendation. See the following link for a complete list of recommendations: http://dcmathpathways.org/resources/task-force-report-arkansas-math-pathways-task-force-recommendations
5. A Missouri state task force recommendation. See the following link for a complete list of recommendations: http://dcmathpathways.org/sites/default/files/2016-08/Report%20of%20the%20Missouri%20Mathematics%20Pathways%20Task%20Force%20on%20Building%20Math%20Pathways%20into%20Programs%20of%20Study.pdf
6. An Oklahoma state task force recommendation. See the following link for a complete list of recommendations: http://dcmathpathways.org/sites/default/files/resources/2017-02/Oklahoma%20Math%20Pathways%20Task%20Force%20Recommendations_final.pdf
7. www.dcmathpathways.org
8. Some four-year institutions require all students to show proficiency in intermediate algebra; thus, community college students intending to transfer to these institutions may be advised away from statistics or quantitative reasoning courses that do not require intermediate algebra as a pre-requisite, even if these courses are most appropriate for their program of study.
9. This and all the remaining quoted statements in the report are from interviews with state task force members.
10. For more information about the Dana Center's transfer policy work, see Krueger (2018).
11. Course equivalencies tables show which courses are transferable between Oklahoma public colleges and institutions (as well as some private institutions). Each table displays equivalent courses at each college and university and is organized by academic discipline. See them at https://www.okhighered.org/transfer-students/course-transfer.shtml
12. Titled "A Process for Success: Developing and Supporting Student Learning Outcomes for Multiple Math Pathways," the document can be found at: https://www.dcmathpathways.org/sites/default/files/resources/2017-03/A%20Process%20for%20Success%20-%20Developing%20and%20Supporting%20Student%20Learning%20Outcomes%20for%20Multiple%20Math%20Pathways.pdf
13. Results of Arkansas's survey to align mathematical content to programs of study are found in Korth, Yu, Watson, Strecker, and Martin (n.d.).

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