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Available at **www.dcmathpathways.org/learn-about/emerging-issues-mathematics-pathways**

Chapter 7

Dana Center Mathematics Pathways (DCMP) Theory of Scale:

Exploring State-Level Implementation Successes and Challenges

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Abstract

In 2014, the Charles A. Dana Center at The University of Texas at Austin developed a theoretical model called the Dana Center Mathematics Pathways (DCMP) theory of scale, which defined a four-phase approach to coordinating, implementing, and scaling multiple mathematics pathways across diverse higher education ecosystems. This chapter highlights how the Dana Center has supported the four phases of system- and institutional-level engagement through its work across the country. An exploration of strategies within each phase is examined alongside successes and challenges encountered in six states that were engaged in the Dana Center Mathematics Pathways to Completion (MPC) project.

Introduction

National data reveal that 60 percent of incoming students at two-year postsecondary institutions are placed into at least one developmental mathematics course each year. Many students must complete several developmental courses before becoming eligible to take college-level mathematics courses. Only 33 percent of these students complete the developmental mathematics sequence, and only 20 percent complete a college-level mathematics course (Bailey, Jeong, & Cho, 2009).

In response to these trends, in 2012, the Charles A. Dana Center launched the implementation of the Dana Center Mathematics Pathways (DCMP) model in nine Texas two-year postsecondary institutions in conjunction with the Texas Association of Community Colleges. The work called for the reform of developmental and gateway mathematics programs in higher education institutions following a systemic approach to improving student success (see Charles A. Dana Center, n.d.). The DCMP model is based on the four principles of multiple mathematics pathways aligned to programs of study, acceleration, integrated student learning strategies, and evidenced-based instruction and pedagogy (Cullinane, Fraga Leahy, Getz, Landel, & Treisman, 2014). This chapter examines the DCMP theory of scale, its four-phase approach to system- and institutional-level engagement, and how the Dana Center has supported its work to scale the DCMP model across the country. To highlight the DCMP theory of scale and its four-phase approach, successes and challenges of state and institutional expansion of the DCMP model are identified for stakeholders who are interested in implementation.

The DCMP Theory of Scale: Implementation Across Higher Education Ecosystems

Propelled by the Dana Center's experiences with its DCMP model in Texas, the Center published the Dana Center Mathematics Pathways (DCMP) theory of scale in 2014, which offers a multi-faceted approach to coordinating, implementing, and scaling multiple mathematics pathways across diverse higher education ecosystems. The basis of the DCMP theory of scale is to support the Dana Center's evolving approach to scale the DCMP model and the process for its enactment.

The DCMP theory of scale draws upon Rogers' (1995) diffusion of innovation theory, Coburn's (2003) conceptualization of breadth and depth of scale, DiMaggio and Powell's neo-institutional theory (1983), and Kingdon's three streams theory (1984) to postulate the essential behaviors, attitudes, and actions that are necessary to influence sustainable "change at scale" (Cullinane et al., 2014). The DCMP theory of scale presumes that established processes and strategies across multiple educational ecosystems and phases of work could result in normative, sustained practice for all students enrolled in mathematics pathways. The pinnacle of the DCMP's theory is the concept of **change at scale**, defined as implementation of mathematics pathways *across* all public institutions (breadth) and *deeply* within institutions (depth) so that all students are engaged in high-quality, rigorous, and well-supported learning experiences. Figure 1 illustrates change at scale across multiple educational ecosystems.

Supporting All Students: Attending to Non-cognitive Factors

The task of supporting students on the pathway to calculus requires reflection about non-content issues that create barriers for underrepresented STEM students like women and underrepresented minority students. To broaden participation in STEM fields and fully realize the potential of mathematics pathways, mathematics faculty should work to minimize the negative impacts of three critical non-cognitive factors: lack of sense of belonging, lack of self-efficacy, and stereotype threat. Although these non-cognitive factors are relevant to student success across disciplines, strategies to reduce their negative impacts can be applied effectively in mathematics courses.

A sense of belonging reflects the feeling that one fits in, belongs to, or is a member of the mathematics community. A healthy sense of belonging is a significant predictor of one's intent to pursue mathematics in the future (Good et al., 2012). Strategies that enhance students' sense of belonging can be as simple as an instructor noticing that a student is absent and then contacting the student. Slightly more involved strategies include holding class discussions about effective work groups and developing classroom norms for working in collaborative groups. Self-efficacy, or one's belief in their ability to succeed, also plays a role in broadening participation in STEM programs, especially in the retention of women and underrepresented minorities. Women are 1.5 times more likely to leave STEM after completing calculus due to a lack of self-efficacy (Ellis et al., 2016).

To further enhance students' feelings of belonging and self-efficacy, institutions should leverage an important feature of the mathematics pathways movement: alignment of college algebra and precalculus courses to STEM programs that require calculus. Successfully aligning mathematics to programs of study leverages the use of contextualized mathematics that is meaningful to students. Contextualized mathematics provides opportunities for students to explore different approaches to problem solving at different levels of formality, and makes mathematics more accessible and more likely to engage students in learning (Van den Heuvel-Panhuizen, 1999; Widjaja, 2013). From a cognitive perspective, contextualization promotes transfer of learning and retention of information (Boroch et al., 2007), which increases the probability of success in calculus and, consequently, student self-efficacy.

Stereotype threat contributes to the underperformance of women, African Americans, Latinos, and other minorities in mathematics (Aronson & Steele, 2005). At its core, stereotype threat is characterized by activated stereotypes that, when left unchecked, trigger a number of disruptive psychological processes that can undermine student performance (Croizet et al., 2004). The experience of being in a numeric minority in academic environments where stereotypes are part of the dominant culture reduces individuals' self-efficacy, especially in the face of difficulty, even if their actual performance is objectively the same as majority-group members (Dasgupta, 2011). A learning environment that utilizes group work, makes student learning visible, and showcases different student approaches to solving challenging mathematical problems can have a significant positive impact on student self-efficacy by making it evident that everyone must work hard to succeed. This in turn may diminish stereotype threat (Asera, 2001).

A recent study of the calculus redesign at Boise State University indicates that the core elements of frequent group work, making learning visible through active and collaborative learning, and

Figure 1. Change at scale requires work at multiple levels of the system

contextualization produced sizable, sustainable, and statistically significant gains in Calculus I pass rates and grades (Bullock et al., 2016). The Dana Center's position is that change at scale must involve effort at all levels of the higher education ecosystem. At the national level, the Dana Center joins national leadership organizations and mathematics professional associations to advocate for multiple mathematics pathways as a means to increase equity and access for all students (see a list of collaborators at www.dcmathpathways.org/dcmp/our-collaborators). The Dana Center's work at the state level (or system level) coordinates and promotes scaling of mathematics pathways through a mathematics task force to develop recommendations for multiple mathematics pathways, and to enact such recommendations and policy-enabling conditions to support statewide implementation. Finally, at the institutional and classroom levels, the Dana Center provides a process, resources, and tools to institutional stakeholders in order to implement and scale mathematics pathways as sustained, normative practices. Early experimentation at the local, institutional, and classroom levels has raised new ideas that inform and influence higher levels of the system.

The DCMP theory of scale describes a system- and institution-level engagement framework for how sustained change at scale can be enacted. This framework (see Figure 2) involves four phases of work necessary for full-scale implementation of mathematics pathways into sustained, normative practice (Cullinane et al., 2014).

Figure 2. DCMP theory of scale's phases of work for system- and institutional-level engagement

Table 1 further defines the four phases of system- and institutional-level engagement and the established strategies within each phase to move toward sustained scale.

Table 1. DCMP theory of scale's phases and strategies for system- and institutional-level engagement

Phase	Strategies
Phase 1. Build urgency and motivation for change through a state mathematics task force.	• Create a collective agenda. • Define the problem with state- or system-level data.
Phase 2. Create an environment and supports for statewide implementation.	• Coordinate action across all levels of the educational ecosystem. • Establish multiple working groups to enact task force recommendations.
Phase 3. Enact multiple mathematics pathways at the institution(s).	• Seek and define early engagement with institutions. • Provide tiered engagement and the corresponding supports.
Phase 4. Support deep and sustained scale.	• Intentional structures for sustainability of change.

The Dana Center's Mathematics Pathways to Completion (MPC) Project

In 2015, the Dana Center launched the Mathematics Pathways to Completion (MPC) project as a major effort to support six states—Arkansas, Massachusetts, Michigan, Missouri, Oklahoma, and Washington—to move from the broad theoretical vision for mathematics pathways to institutional implementation of the Dana Center Mathematics Pathways model over three years. In the MPC project, each of the six states engaged in processes, strategies, and phases defined by the DCMP theory of scale. The Dana Center provided direct support in the form of consultations, resources, and tools. As a result of the MPC project, the Dana Center learned valuable lessons about operationalizing the DCMP theory. The MPC states' strategies, successes, and challenges in implementing the DCMP theory of scale are presented below, followed by findings and recommendations for future work.

Strategies, Successes, and Challenges of Phase 1 of the MPC Project

When implementing the DCMP theory of scale and building motivation for change in Phase 1, the Dana Center recommended that MPC states create state-level task forces comprised of mathematics faculty from both two-year and four-year institutions. The Dana Center charged the state-level task forces to create a collective agenda about implementing mathematics pathways that involved defining the problem being addressed, using state- or system-level data as evidence, and developing recommendations to address the problem. Each MPC state published, disseminated, and championed mathematics pathways recommendations as an outcome of Phase 1.

The objective of creating the collective agenda was to build both urgency and motivation for change at scale. An immediate priority when creating a collective agenda is to bring stakeholders together to lead the work. Prior to the MPC project, the Dana Center's efforts to support state-level implementation had not prescribed the composition of the leadership team and its task force members. This had presented challenges in institutional representation on state-level task forces as one or more sectors of higher education were lacking, or one sector was unequally represented over another. Uneven representation by either two- or four-year institutions presented a challenge to state-level task forces as the overrepresented sector was positioned to dominate the collective agenda. Consequently, beginning with the MPC project, the composition of the state-level work group charged with creating the collective agenda intentionally included members from both two- and four-year institutions across the state, who were carefully selected to represent broad engagement of mathematics faculty.

In creating the collective agenda, it was also critical to define the problem and its underlying drivers that mathematics pathways would address, particularly in the context of the use of state- or system-level data as evidence of the problem. Collecting data to define and support the problem proved to be challenging for MPC states. Some states have a highly decentralized system of higher education governance in which two- and four-year institutions have high degrees of autonomy and are primarily linked by sector and disciplinary affiliations and/or local articulation agreements. Such loosely defined systems might collect and analyze their own data but rarely engage in organizing or sharing with others to garner a bigger picture of state- or system-level problems. Furthermore, mathematics pathways initiatives are relatively new systemic innovations that require in-depth analysis of data metrics that might not be a part of current data collection processes. These challenges often hinder the use of data across higher education ecosystems. However, ingenuity prevailed in Phase 1 of the MPC project as states' task forces looked at national data or data collected for other related initiatives (e.g., guided pathways) to help them define their problem (while also initiating improvements for future data collection activity).

Strategies, Successes, and Challenges of Phase 2 of the MPC Project

In Phase 2, extensive work across higher education ecosystems and stakeholder groups in the MPC states centered on creating an environment to support statewide implementation. Initial efforts focused on creating policy and practice conditions for statewide implementation. Most state-level task forces established working groups focused on specific areas (e.g., transfer and applicability, student learning outcomes, professional development) to plan and take action towards the state's recommendations (see Table 2). Working groups in the MPC states consisted of representatives of higher education stakeholder groups, and were charged with addressing the "nuts and bolts" of carrying out the recommendations related to higher education ecosystems. For example, in Arkansas, working groups were established to enact recommendations outlined in their task force recommendations report (Arkansas Math Pathways Taskforce, 2017).

Table 2. Arkansas working groups supported by the Dana Center

Working Group Purpose	Involved Higher Education Ecosystems	Stakeholder Groups
Transfer and Applicability	State, System, and Institution	Administrators, Faculty, Policymakers, and State Agency Staff
Multiple Measures	System and Institution	Administrators, Faculty, and Advisors
Faculty Professional Development	Institution and Classroom	Administrators, Faculty, and Advisors
Arkansas Course Transfer System (ACTS) Language	State, System, and Institution	Policymakers, State Agency Staff, and Faculty

A common challenge when coordinating long-term action across higher education ecosystems is burnout. Missouri—a state that had been supported by the Dana Center under the Building Math Pathways to Programs of Study (BMPPS) initiative from 2014 to 2016, and through the MPC project—faced this particular obstacle. During Phase 2 of the MPC project, both system- and institutional-level stakeholders across Missouri devoted countless hours to a multitude of tasks related to implementation of mathematics pathways, including up to eight task force meetings a year, active engagement in state- and institutional-level workshops, communication and engagement outreach, and multiple working groups. This level of active, long-term engagement with the MPC project led to positive results across the higher education ecosystem, but it also strained task force members. In order to combat burnout, the state intentionally divided its final year of activity under the MPC project into a regional approach so that institutions within each region would enhance their commitment, improve discussions among transfer partners, and equally distribute responsibilities for math pathways implementation.

Strategies, Successes, and Challenges of Phase 3 of the MPC Project

During Phase 3, responsibility for implementing mathematics pathways shifted from the state-level task forces to institutional leadership teams. Leveraging the action that had been taken in Phases 1 and 2, MPC state-level task forces secured institutional commitments (e.g., letters of commitment, memorandum of understanding) from institutional leadership teams that defined their roles and responsibilities for implementing the mathematics pathways. Securing early institutional engagement and commitment helped institutions gain equal access to resources, tools, and support (e.g., professional development, site visits). Although implementation responsibility shifted to institutional leadership teams during this phase, the state-level task force was still active and was charged with monitoring and supporting ***all*** public two- and four-year institutions through tiered engagement.

Tiered engagement is defined by two categories: early implementer institutions and late implementer institutions. In both tiers, resources, tools, and support were identified, defined, and prioritized to ensure that all institutions were able to engage in the MPC project in some manner. Table 3 identifies the tiered engagement and corresponding supports provided by the state-level task forces across the MPC states.

Table 3. Types of support for tiered engagement in mathematics pathways across MPC states

Types of Support	Offered to...	
	Early Implementer Institutions	Late Implementer Institutions
Professional development workshops (e.g., co-requisite, advising)	X	X
Site visits and/or 1-on-1 biannual leadership team calls	X	
Resources and tools to support institutional leadership teams, available from DCMP resource site	X	X
Regular communication and engagement of mathematics pathways activities	X	X

Note: Professional development workshops are tailored to support early implementer institutions and are offered to both early and late implementer institutions.

In order to initiate Phase 3 strategies, each MPC state hosted a Designing Mathematics Pathways workshop for all two- and four-year institutions regardless of their institutional commitment or designation to a tier-of-engagement for the MPC project. This initial opportunity empowered each institution to learn about the MPC initiative in their state and easily identify their institution's readiness to commit and the necessary resources to support its efforts.

Those MPC states that strategically engaged their institutions early in the MPC project experienced large-scale success in securing institutional comments and identifying tiered engagements. For example, in Phase 1 of the MPC project, Arkansas and Oklahoma, which were working independently, established their state-level task force memberships with representatives from all public higher education institutions in their respective states. This early state-level engagement, with representatives from all public higher education institutions serving on the task force, fostered success for both states to achieve their scaling strategy (in Phase 2) by gaining institutional commitments from most, if not all, two- and four- year institutions as early implementers in the MPC project. Across other MPC states, strategic recruitment efforts secured a cohort of committed institutions as "early implementers." For a list of MPC states' secured institutional commitments, see *Implementation Connect* (Charles A. Dana Center, 2018).

Strategies, Successes, and Failures of Phase 4 of the MPC Project

The final phase involves developing a sustainability plan in each MPC state that defines intentional structures (processes and strategies by both state- and institutional-level stakeholders) needed to sustain change at scale beyond the MPC project timeline (November 2018). This strategy of embedding structures for deep and sustained change at scale is crucial to move a pilot innovation to sustained practice. The outcome of Phase 4 is normative, sustained, and institutionalized practice for all students in a state and its higher education institutions with regard to mathematics pathways. Commitment to structures that would support the sustainability of mathematics pathways and change at scale was an initial and ongoing requirement for all MPC states. In the initial application process, states committed to the key sustainability of scale structures (see Table 4).

Table 4. Intentional structures for sustainability of mathematics pathways

Intentional Structures for Sustainability of Mathematics Pathways
• Establish a "home" for the work.
• Collaborate with policy agencies.
• Collaborate across two- and four-year institutions.
• Connect the work across developmental and gateway mathematics courses.
• Implement mathematics pathways based on the DCMP model.
• Cover costs to support project activities.

Not only were intentional structures embedded in the initial commitment to the project and throughout Phases 1–3, but they were also fostered in discussions to support self-funding beyond the project. This self-funding was secured through means such as legislative budget appropriations, higher education funding formula amendments, or reallocation of resources through institutional strategic plans. For example, Michigan secured legislative appropriations within its 2018 budget for an estimated $1 million dollars to support multiple mathematics pathways work by expanding the Michigan Transfer Network. This network is aimed to support faculty professional development opportunities, align mathematics courses to programs of study, and improve access to data across Michigan's institutions.

In the Fall 2017, Arkansas repealed its needs-based and outcome-centered higher education funding formula to a productivity-based funding model to align with statewide goals for higher education across two- and four-year institutions (Arkansas Department of Higher Education, 2017a, 2017b). Effectiveness, a dominant (80 percent) category of Arkansas's productivity-based funding formula, encompasses credentials, progression, transfer success, and gateway course success to include mathematics. The self-funding efforts of Michigan and Arkansas are establishing intentional structures for sustained change at scale for mathematics pathways.

The greatest challenge for Phase 4, which is yet to be realized, is enactment of sustainability plans over time and maintaining momentum beyond the scope of the MPC project.

Conclusion

Based on observations and experiences from the Dana Center's MPC project, important conclusions were made about the practicality of scaling the DCMP model beyond Texas, that is, the Dana Center's processes and strategies as developed in the DCMP theory of scale to support implementation and scaling of mathematics pathways in terms of breadth and depth to improve student completion. These conclusions are:

- ✓ The key to change at scale of mathematics pathways involves both reliable processes and strategies from the Dana Center and adapting support to each state's context.
- ✓ Empowering customization to local needs is essential to the sustainability of mathematics pathways (e.g., policy environment).

For the Mathematics Pathways to Completion project, successful state- and institutional-level implementation across Phases 1–3 involved using Dana Center processes and strategies, as well as the Center's resources, tools, and advisory support. At the same time, each state still retained a high level of autonomy and flexibility to implement mathematics pathways that were congruent with local contexts. As the Dana Center works across diverse higher education ecosystems and states, continuous improvement of its processes and strategies is a priority, particularly as the Dana Center learns from local leaders about how best to leverage local educational and policy environments to support the implementation and scale of mathematics pathways.

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