Chapter 3
Improving Secondary Mathematics Teacher Preparation Via a Networked Improvement Community: Focus On Clinical Experiences

W. Gary Martin and Marilyn E. Strutchens

Abstract The Mathematics Teacher Education Partnership is a consortium of over 90 U.S. universities and colleges, along with partner school districts, focused on improving the initial preparation of secondary mathematics teachers. The Partnership uses a Networked Improvement Community design that incorporates improvement cycles to develop adaptable interventions across contexts, as well to scale interventions across the Partnership to support comprehensive program improvement. Rather than addressing a single dimension of a secondary mathematics program, the Partnership is undertaking parallel lines of research in multiple areas. To illustrate the power of the approach, this chapter will more deeply explore one of those lines of research related to clinical experiences: A "research action cluster" (RAC) consisting of representatives of 24 university-led teams is working to improve the clinical experiences of secondary mathematics teacher candidates. This RAC has employed improvement science methods to developed resources that support improved models for both student teaching and early field experiences, as well as professional development for mentor teachers.

Keywords Mathematics education · Teacher preparation · Clinical experiences Secondary mathematics · Improvement science

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3.1 Introduction

3.1.1 Rationale

The U.S. continues to struggle to ensure that its students have the mathematical preparation needed for future success. For example, in the 2015 National Assessment of Education Progress, which periodically "measures students' knowledge and skills in mathematics and students' ability to apply their knowledge in problem-solving situations" (The Nation's Report Card, 2017), only 25% of twelfth-grade students demonstrated a level of proficiency needed for future success. Moreover, there has been little improvement in scores over the past decade (The Nation's Report Card, 2017). A similar result can be seen in results from the Programme for International Student Assessment in 2015, in which only 20% of U.S. 15-year old students exceeded the third proficiency level of six, and the U.S. average score fell in the bottom half of industrialized nations (National Center for Educational Statistics [NCES], 2017).

One explanation for the inadequate preparation of U.S. students in mathematics may be found in the significant shortage of well-prepared secondary mathematics teachers in the country. More than 1 in 6 secondary schools report "serious difficulties" in filling vacant mathematics teaching positions (Ingersoll & Perda, 2010). According to the NCES (Keigher, 2010), 1 in 12 secondary mathematics teachers leave the profession every year. The attrition rate is particularly high for beginning mathematics teachers; almost 1 in 7 leave teaching after their first year (Ingersoll, Merrill, & May, 2012). Moreover, quality of mathematics instruction continues to be a concern, as seen in two national surveys of practicing secondary mathematics teachers (Banilower et al., 2013; Markow, Macia, & Lee, 2012): only half reported using instructional practices and goals aligned with the Common Core State Standards for Mathematics (CCSSM) (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010).

Thus, the preparation of secondary mathematics teachers in the U.S. requires addressing the interlocking issues of the quantity and quality of those entering the profession. The systemic nature of these issues is illustrated in Fig. 3.1, which depicts a downward cycle in mathematics teacher preparation in the U.S., adapted from Wilson (2011). The cycle begins at the top with the inadequate preparation of U.S. students in mathematics; note that K–12 denotes students in precollege education from kindergarten (K) through grade 12, the final grade in U.S. precollege education. Moving to the right, this implies that the pool of students who are adequately prepared to enter mathematics teaching as a career is quite small; moreover, well-prepared students have many options and so may not choose to enter teaching. Continuing to the lower right of the cycle, mathematics teacher preparation programs often do not provide candidates with the mathematics knowledge needed for teaching (cf. Ball, Thames, & Phelps, 2008). At the bottom of the cycle, candidates may not have clinical experiences that support their development of effective teaching practices (Horn & Campbell, 2015).

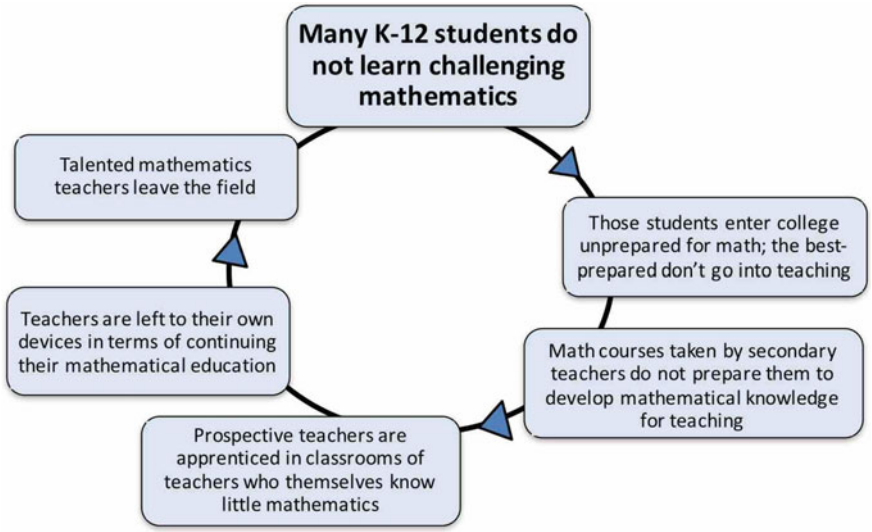

Fig. 3.1 The downward cycle in mathematics teacher preparation (adapted from Wilson, 2011)

Those candidates who enter the teaching profession, lower left of the cycle, often have little support for their continuing growth (Horn & Campbell, 2015), with the result that many talented teachers leave the profession. And we return to the top of the cycle, where many students continue to receive an inadequate preparation in mathematics.

3.1.2 Formation of the Partnership

To address the challenge presented in this downward cycle—the undersupply of new secondary mathematics teachers who are well prepared to help their students attain the goals of the CCSSM and other rigorous state mathematics standards—the Association of Public and Land-grant Universities (APLU) formed the Mathematics Teacher Education Partnership (MTE-Partnership), a national consortium of over 90 universities and over 100 school systems, as a project within its Science and Mathematics Teaching Imperative (SMTI), which focuses more generally on improving mathematics and science teaching. APLU is an organization of major state universities within the U.S., particularly focused on addressing issues related to higher education and its leadership.

The initial concept for the Partnership was formed at the 2011 SMTI Annual Conference, which focused on how higher education might respond to the just-released CCSSM, including necessary changes in teacher preparation. A group of attendees submitted a white paper to the SMTI executive committee proposing

the formation of the project, and a planning team was formed to organize the Partnership. Funding from the National Science Foundation (#1147987) supported the development and launch of the network in Spring 2012, and subsequent grants from the Leona M. and Harry B. Helmsley Charitable Trust have supported its continuing development.

The goal of the Partnership is to "transform secondary mathematics teacher preparation" (MTE-Partnership, 2014, p. 1). University programs participate in the Partnership as a part of teams that include K–12 school districts and other partners involved in secondary mathematics teacher preparation, with a requirement that teams engage mathematics teacher educators, mathematicians, and K–12 personnel in their activities. The inclusion of multiple stakeholders in the efforts reflects the focus of the partnership on "develop[ing] and promot[ing] a common vision and goals for how to best prepare teacher candidates who can promote student success in mathematics" within a program, as well as engaging in mutual learning and sharing responsibility across the Partnership (MTE-Partnership, 2014, p. 2). There are currently 39 partnership teams across 31 states in the U.S. (see Fig. 3.2).

3.1.3 Research Design

About a year after its formation, the MTE-Partnership adopted the Networked Improvement Community (NIC) model developed and used by the Carnegie

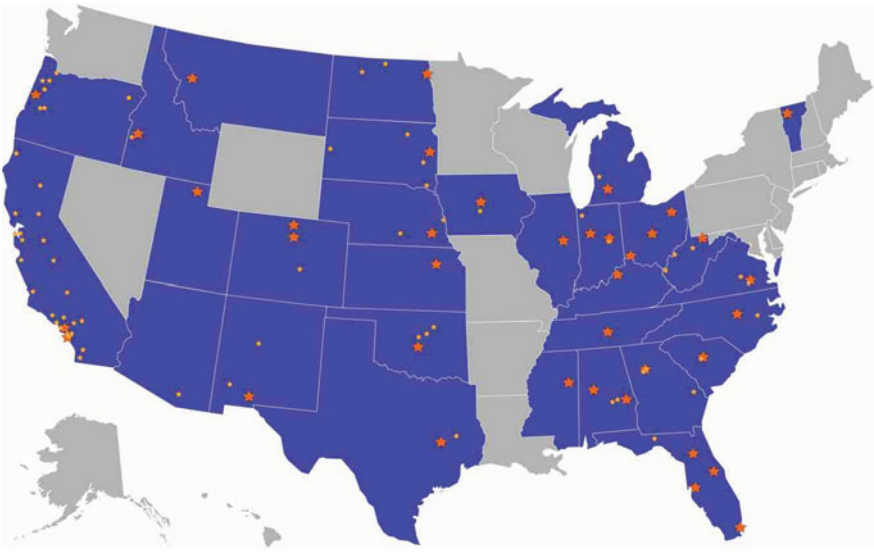

Fig. 3.2 Participation in the MTE-Partnership. Large stars represent lead institutions for a team, and small stars represent other participating universities and colleges

Foundation for the Advancement of Teaching in response to several design challenges identified by the planning team, including (a) the need to maintain the engagement of the teams in the work of the Partnership and (b) the need to maintain a focus on disciplined inquiry consistent with the mission of universities (Martin & Gobstein, 2015). This design supports active collaboration by the partnership teams to address significant issues in secondary mathematics teacher preparation using improvement science to ensure fidelity to academic standards of inquiry. While no explicit theoretical stance was adopted in the work, as its focus is more on building solutions to problems than on building theory, the emphasis on collaborative building of knowledge is consistent with social constructivism (Ernest, 1991).

NICs are distinguished by four essential characteristics (Bryk, Gomez, Brunow, & LeMahieu, 2015); each characteristic is described in the following, along with how the Partnership addressed that characteristic.

- **Focused on a specified common aim**: The Partnership is focused on the twin aims of producing mathematics teacher candidates who meet a "gold standard" of preparedness to address the Common Core and of increasing the quantity of well-prepared candidates by Partnership programs by 40% by 2020, as depicted in the left-most column of Fig. 3.3. Note that the improvement target was set through a collaborative process of collecting data from the individual teams and programs. Further information on the measures used to assess candidate quality is given in a later section of this chapter.

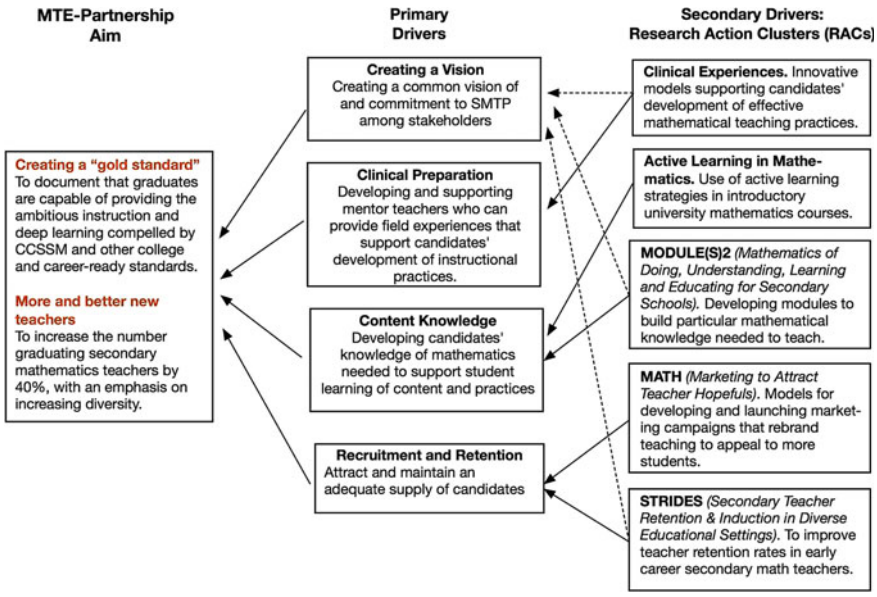

Fig. 3.3 The MTE-Partnership driver diagram (Martin & Gobstein, 2016)

- **Guided by a deep understanding of the problem and the system that produces it**: Over a period of nearly a year, the membership teams worked together to develop a shared vision for the Partnership, which is reflected in its *Guiding Principles for Secondary Mathematics Teacher Preparation* (MTE-Partnership, 2014). This document then formed the based for identifying challenges in secondary mathematics teacher preparation. A multi-step process described by Martin and Strutchens (2014) led to the identification of four significant problem areas of primary importance to the Partnership. In the second column of Fig. 3.3, these problems are restated in the positive as primary drivers, the Partnership's main areas of influence necessary to promote movement towards achieving the aim (Bryk et al., 2015). Note that these primary drivers are well-aligned with the Standards for Program Characteristics and Qualities in the *Standards for the Preparation of Teachers of Mathematics* released by the Association of Mathematics Teacher Educators (AMTE) (2017).
- **Disciplined by the rigor of improvement science**: The use of evidence to guide the development of interventions ensures that the changes being proposed are actually improvements. Moreover, use of an iterative cycle of prototyping, testing, and refining interventions, as seen in Fig. 3.4, has the potential to lead to timely solutions to important problems (Bryk et al., 2015). "Research action clusters" (RACs) have been organized to carry out the development of interventions. The current RACs are summarized in the third column of Fig. 3.3. More detail is provided in the following section.
- **Networked to accelerate the development, testing, and refinement of interventions and their effective integration into varied educational contexts**: Rather than trying to "control" variation, as typical in traditional

Fig. 3.4 The Plan-Do-Study-Act (PDSA) cycle (adapted from Langley et al., 2009)

educational research, the Partnership's design embraces variation to study how interventions need to be adapted to respond to the differing conditions under which they are used. As they are tested and refined, interventions can gradually spread across the network, supporting scale up (Bryk et al., 2015). Thus, rather than developing a "treatment" that is tested against a control group, the initial development and testing of an intervention begins in a small number of settings. As its efficacy is demonstrated, it is tested in an increasing number of settings, noting adaptations that are needed due to differences in the context. Eventually, the interventions designed should be useful by teams across the Partnership. Further note that the structure of the network allows a "divide and conquer" approach in which subsets of teams can address different problem areas, providing teams access to a wider range of interventions as the work of the RACs progresses.

3.2 Areas of Inquiry

3.2.1 Formation of Research Action Clusters

Working groups, each including teams from across the MTE-Partnership, were formed to further analyze the four primary drivers described in Fig. 3.3. In addition to conducting reviews of existing literature related to the driver diagram, a survey of Partnership teams provided more detail about particular challenges they faced in each area. This analysis resulted in a series of white papers that have guided the continuing work of the Partnership. Each working group proposed potential areas of action or "change ideas" for achieving their respective primary drivers. Across the working groups, an initial set of 13 proposed change ideas were put forward. Based on further analyses of priority and interest by the teams, this set was pared down to five. A "research action cluster" (RAC) was established by the Partnership to begin work on each of these change ideas. Partnership teams were invited to join these RACs in fall 2013; each team generally joined one or two RACs.

Note that one RAC was later disbanded due to its inability to form a clear plan of action, and an additional RAC was formed summer 2015 to address an emergent area of concern, induction of candidates into the profession. An additional working group is currently working to build the foundations for a new RAC that considers how programs can integrate findings from the existing RACs to support overall program transformation, with a focus on institutional change. Thus, the network is evolving based on the needs of its partner institutions. Each RAC incorporates the NIC design, using improvement cycles to develop interventions addressing an identified aim.

Figure 3.3 represents the present structure of the Partnership, including the current set of five RACs, how they are related to primary drivers identified for the Partnership, and the overall aim for the Partnership. Note that none of the change

ideas related to Creating a Vision were initially addressed by a RAC; however, most of the other RACs indirectly address this primary driver, and the new RAC addressing program transformation may more directly address it. A brief summary of each of the RACs follows:

- The Marketing to Attract Teacher Hopefuls (MATH) RAC is developing marketing strategies to attract students to consider secondary mathematics teaching as a career.
- The Actively Learning Mathematics (ALM) RAC is focusing on improving the content preparation of candidates in introductory university mathematics classes, precalculus through calculus 2, using "active learning" strategies (Freeman et al., 2014) and incorporating the use of learning assistants (Webb, Stade, & Grover, 2014).
- The Mathematics of Doing, Understanding, Learning and Educating for Secondary Schools [MODULE(S^2)] RAC is producing modules or courses specifically aimed at developing mathematical knowledge for teaching (cf. Ball et al., 2008) in alignment with the recommendations of the *Mathematics Education of Teachers II* report (Conference Board of Mathematical Sciences, 2012). Initial development work has begun in the areas of transformational geometry, modeling, and statistics.
- The Clinical Experiences RAC is focusing on improving clinical experiences, including experimenting with new models for both student teaching (cf. Leatham and Peterson, 2010b) and early field experiences, as well as professional development for mentor teachers.
- The Secondary Teacher Retention and Induction in Diverse Educational Settings (STRIDES) RAC is considering ways to increase the number of years that early career secondary mathematics teachers completing Partnership programs remain in the field.

3.2.2 *Collective Impact of the Research Action Clusters*

In support of the MTE-Partnership aim and drivers, each RAC has developed its own aim and driver diagram for its area of concern. In essence, each RAC forms a NIC within the broader NIC, and in some cases subgroups within the RACs have further focused in on particular issues, thus creating a nested structure of improvement work. Collectively, these RACs address the downward cycle discussed at the start of this paper; Fig. 3.5 depicts the contribution of each RAC.

While the RACs are progressing at different rates, interventions found effective by the RACs in addressing significant problems in secondary mathematics teacher preparation are beginning to emerge and can be adopted by additional Partnership teams not involved in their development. For example, based on its research, the MATH RAC has produced the *Secondary Mathematics Teacher Recruitment Campaign Implementation Guide* (MTE-Partnership, 2015) which is designed to

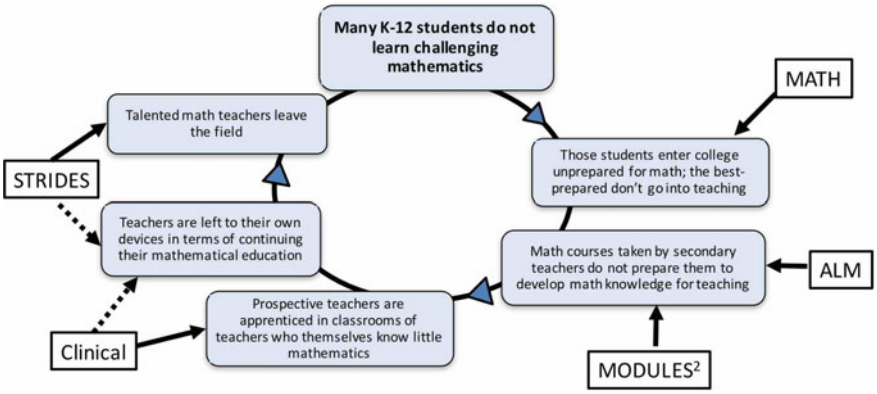

Fig. 3.5 Addressing the downward cycle in mathematics teacher preparation

"help faculty members and others within mathematics or STEM teacher education programs maximize their impact on teacher candidate recruitment" (Overview Module, p. 2). The RAC is also collecting specific examples of how the guide can be adapted in various contexts. The Actively Learning Mathematics RAC has developed professional development materials for instructors, a series of activities, and other supports for promoting active learning in introductory college mathematics. The MODULE(S^2) RAC has produced modules that instructors can use to increase the knowledge of geometry and statistics needed by secondary teachers; these materials are being tested by faculty members across the Partnership. The Clinical Experiences RAC has developed professional development and other materials to support the implementation of innovative approaches to early field experiences and to full-time internship experiences; more detail is provided later in the chapter.

3.2.3 Measures

The activities of the MTE-Partnership are designed to support progress towards meeting the aim established in the NIC design, and a suite of measures has been devised to track progress towards the overall MTE-Partnership aims. A measures working group, which includes members from each of the RACs, was established to guide this effort. To address the first aim of the Partnership to increase the supply of new secondary mathematics candidates, the group collects data on the production of teacher candidates by membership teams on an annual basis. Baseline data suggested that the Partnership produces about 15% of the supply of secondary mathematics teachers in the U.S. Teams also provided targets for increasing their candidate production, which led the MTE-Partnership to establish a target of increasing candidate production by 40% from 2014 to 2020, which would be about 20% of the national supply, assuming steady demand for teachers.

The measures working group is also identifying or developing measures that can be used to track progress towards the second Partnership aim of improving the quality of candidates graduated. Given that programs have existing measures in place, often required by certifying agencies, establishing common measures across the Partnership has been particularly challenging. A common observation protocol, the Mathematics Classroom Observation Protocol for Practices (MCOP2) (Gleason, Livers, & Zelkowski, 2015) was selected for use across Partnership programs. While programs may not be able to replace the protocols they currently use, they are being asked to use the MCOP2 with a sample of teacher candidates at the conclusion of their culminating student teaching experience as a common data point across programs. The MCOP2 is additionally used by several RACs to track their progress towards their specific RAC aims.

The measures working group has also developed a survey for teacher candidates completing Partnership programs to self-assess their preparedness as they begin their careers as secondary mathematics teachers based on the *Guiding Principles* (MTE-Partnership, 2014) and the Mathematics Teaching Practices (NCTM, 2014). In addition, the measures group oversees an annual program survey in which team leaders self-assess the effectiveness of their program in preparing candidates in alignment with the *Guiding Principles* (MTE-Partnership, 2014).

While each measure in isolation provides a limited picture of the quality of the candidates being produced by Partnership programs, triangulating the data across the measures may provide more complete evidence of programs' success in ensuring the quality of the teachers they produce. Additional measures are being considered to garner input about candidate quality from additional sources, such as candidates' eventual employers, and to address additional dimensions of candidate quality, such as mathematical knowledge for teaching. Such measures will add both depth and breadth in understanding the quality of candidates prepared by Partnership programs.

Finally, measures are central to the work of each of the RACs. Each RAC develops, adopts, or adapts measures that can be used to track progress as improvement cycles are implemented and guide decisions about changes that need to be made in the next improvement cycle. Moreover, as testing of the improvements scales up to additional sites, the evidence that is gathered across the range of contexts helps to document specific adaptations that may be needed to address various contextual factors. This ensures that the interventions can be scaled with integrity across the Partnership.

3.3 Research on Clinical Experiences

We now turn our attention to the research action cluster focused on clinical experiences. This is meant to serve as an example of how the MTE-Partnership design has supported the work in one particular research focus, as well as to provide information about the progress made in this research area.

3.3.1 Contextualizing Clinical Experiences

Clinical experiences of secondary teacher candidates, along with content knowledge and the quality of the prospective teachers, have been dubbed as the aspects of teacher preparation that are likely to have the strongest effects on outcomes for students (National Research Council [NRC], 2010). In addition, the *Report of the Blue Ribbon Panel on Clinical Preparation and Partnerships for Improved Student Learning* commissioned by the National Council for Accreditation of Teacher Education [NCATE] (2010) in the U.S. suggests a "*clinically based preparation* for prospective teachers, which fully integrates content, pedagogy, and professional coursework around a core of clinical experiences" (p. 8). Moreover, NCATE (2010) suggests that prospective teachers experience a clinical experience continuum in which a developmental sequence of teaching experiences during the teacher education program is delineated with experiences moving from the simplest, such as learning names, recording grades, and counting the number of students who will eat lunch prepared by the cafeteria or who brought their lunch from home, to the most complex, such as differentiating instruction, developing assessments, and designing and implementing unit plans. These experiences begin in a pre-teaching experience (mainly observational), next a practicum (perhaps teaching a lesson or working with small groups of students) connected to a methods course, and then finally an internship/student teaching experience (gradually taking on teaching responsibilities until the candidate is teaching a full load of classes and then gradually gives the classes back to the cooperating teacher).

In addition, teachers feel that clinical experiences are beneficial to their professional development:

> Study after study shows that experienced and newly certified teachers alike see clinical experiences (including student teaching) as a powerful—sometimes the single most powerful—component of teacher preparation. Whether that power enhances the quality of teacher preparation, however, may depend on the specific characteristics of the field experience. (Wilson, Floden, & Ferrrini-Mundy, 2001, p. 17)

During clinical experiences, prospective secondary mathematics teachers (PSMTs) develop *the craft of teaching*—the ability to design lessons that involve important mathematical ideas, design tasks that will help students to access those ideas, and to successfully carry out the lesson. This may include effectively launching the lesson, facilitating student engagement with the task, orchestrating meaningful mathematical discussions, and helping to make explicit the mathematical understanding students are constructing (Leatham & Peterson, 2010a, p. 115).

Even though it is desirable for prospective teachers to develop the craft of teaching as described, teacher preparation programs in the U.S. and many other countries find it difficult to place PSMTs with cooperating teachers who are prepared to foster their growth due to many cooperating teachers' lack of proficiency with this approach to teaching, which is in alignment with the National Council of Teachers of Mathematics [NCTM] (1989, 1991, 1995, 2000, 2014) standards

documents and other calls (Boykin, 2014; Horn & Campbell, 2015) for inquiry-based and problem- and student-centered instruction. The cooperating teachers' lack of proficiency in using an inquiry approach to teaching may be attributed to their beliefs systems or lack of professional development related to the approach, or a combination of these factors and others.

Furthermore, a bidirectional relationship needs to exist between teacher preparation programs and school partners in which clinical experiences take place. This relationship should reflect a common vision and shared commitment to inquiry-based practices and other issues related to mathematics teaching and learning. Borko, Peressini, Romagnano, Knuth, and Willis (2004) asserted that compatibility of methods courses and student teaching experiences in which PSMTs participate on several key dimensions is essential for the settings to reinforce each other's messages, and thus work in conjunction, rather than in opposition, to prepare reform-minded teachers.

The Clinical Experiences RAC (CERAC) consists of 24 university led teams, each consisting of at least one mathematics teacher educator, a mathematician, and a school partner. Within the different partner-teams the relationship among the team members may vary. For example, for one team the mathematician is able to observe teacher candidates and participate in debriefings; the mentor teacher works well with the interns and the university supervisor, both in mentoring the teacher candidates and in providing information about the implementation of the paired-placement student teaching model in her classroom; and the university supervisor is a program faculty member who is heavily involved in the MTE-Partnership. In this case, the cooperating/mentor teacher does not receive a stipend for her role. The RAC is currently developing and testing models for clinical experiences following the NIC model in alignment with the MTE-Partnership's guiding principles (2014). This work includes fostering partnerships between institutions of higher education, schools and districts, and other stakeholders, in order to prepare teacher candidates who promote student success in mathematics, as described in the CCSSM and other college- and career-ready standards. Higher education faculty and partnering school districts and schools work together to actively recruit, develop, and support inservice master secondary mathematics teachers who can serve as mentors across the teacher development continuum from preservice to beginning teachers. Moreover, this RAC helps to ensure that teacher candidates have the knowledge, skills, and dispositions needed to implement educational practices (NCTM, 2014) found to be effective in supporting all secondary students' success in mathematics.

We are addressing a two-fold problem: (1) There is an inadequate supply of quality mentor teachers to oversee field experiences, particularly those who are well versed in implementing the CCSSM, including embedding the standards for mathematical practice into their teaching. (2) For most universities and their school partners a bidirectional relationship does not exist between the teacher preparation programs and school partners in which clinical experiences take place. Bidirectional

relationships between universities and their school partners need to be built and should reflect a common vision and shared commitment to the vision of CCSSM and other issues in mathematics teaching and learning.

3.3.2 *Structure of the Clinical Experiences RAC*

CERAC is divided into three Sub-RACs, each focused on a particular model for clinical experiences: Methods, Paired Placement, and Co-planning and Co-teaching (CPCT). The Methods Sub-RAC focuses on aligning what is taught to teacher candidates during the coursework and the practicum work in K–12 schools with mentor teachers. Mentor teachers provide teacher candidates with opportunities to experience the authentic work of expert teachers. Furthermore, supervising teacher candidates can encourage the professional growth of mentor teachers (Feiman-Nemser, 1998; Rhodes & Wilson, 2009). Helping to name mentor teacher actions and talk with language used in the theoretical underpinnings more familiar to teacher educators and teacher candidates can better leverage the expertise of the mentor teachers as well as further develop their understanding of the theoretical and mathematical support behind their work. The paired placement model is a student teaching approach in which two prospective teachers are paired with a single cooperating teacher. The cooperating teacher provides purposeful coaching and mentoring, and the two pre-service teachers offer each other feedback, mentoring, and support (Mau, 2013). CPCT is a pedagogical approach that promotes the collaboration and communication between teacher candidates and mentor teachers who share a common space in the planning, implementation, and assessment of instruction (Bacharch, Heck, & Dahlberg, 2010).

In addition to the partnership's aim and driver diagram, each RAC has its own aim and driver diagram. The aim of the Clinical Experience RAC is as follows:

During student teaching, teacher candidates (TCs) will use each of the eight mathematics teaching practices (NCTM, 2014) at least once a week during full time teaching. Below is a list of the mathematics teaching practices (NCTM, 2014, p. 10):

1. Establish mathematics goals to focus learning.
2. Implement tasks that promote reasoning and problem solving.
3. Use and connect mathematical representations.
4. Facilitate meaningful mathematical discourse.
5. Pose purposeful questions.
6. Build procedural fluency from conceptual understanding.
7. Support productive struggle in learning mathematics.
8. Elicit and use evidence of student thinking.

The primary drivers for the Clinical experience RAC are:

(1) **Transparent and coherent system of mentor selection and support** (**cooperating teachers and university supervisors**), which is done within partnerships between school districts and universities focusing on professional development and program specific guidelines;
(2) **Interdependency of methods course and early field experiences**, which focus on embedding the standards for mathematical practice in instruction that utilizes the eight mathematics teaching practices to ensure that each and every student has access to meaningful mathematics learning;
(3) **Student teaching as clinical training**, which ensures that requirements for student teaching and feedback during student teaching emphasize the responsibility of teacher candidates to advance mathematics learning among secondary students through collaboration with more expert mentors in use of mathematics teaching practices;
(4) **Shared vision about teacher development**, which is designed to ensure that there is mutual agreement between district(s) and universities about what quality teaching of secondary mathematics looks like and how to further skills of all teachers (including teacher candidates) and see mentor teaching as part of career ladder;
(5) **Focus on access and equity**, which includes both quality of experiences and opportunities to learn for the students and the teacher candidates. The preparation of each new teacher of secondary mathematics represents an opportunity to disrupt long-standing teaching practices that contribute to inequities in learning outcomes.

Each Sub-RAC is implementing PDSA cycles based on their goals and objectives. There are overlapping areas that focus the RAC as a whole, such as NCTM's mathematics teaching practices, professional development for mentors around the CCSSM, mentoring mathematics teacher candidates, and outcome measures. There are also specific goals to be attained within each of the Sub-RACs, and each Sub-RAC is addressing specific research questions. The three Sub-RACs are using a set of common measures, including:

(1) the MCOP2 (Gleason, Livers, & Zelkowski, 2015), also used as a core measure by the Partnership;
(2) a survey of program completers designed by the MTE-Partnership to show how well prepared the teacher candidates feel based on the experiences that they had in their programs; and
(3) the Mathematics Teaching Practices Survey designed by the RAC to determine the level at which prospective secondary teachers are engaged with NCTM's (2014) Mathematics Teaching Practices.

Each sub-RAC is developing modules and tools that will enable other programs to implement the different approaches to field experiences that they are designing, including: Syllabus and Orientation Session for the Paired Placement Model,

Mathematics Teaching Practice Survey, CPCT Workshops, CPCT Survey, and Standards for Mathematical Practice Module for Methods Courses with Pre- and Post-course Survey.

3.3.3 *Paired Placement Sub-RAC*

We now take a closer look at one of the Sub-RACs in order to better understand the work of the MTE-Partnership. The Paired Placement Sub-RAC is comprised of members representing five institutions and their school partners. The Sub-RAC focuses on the paired placement model for student teaching in which two prospective teachers are paired with a single cooperating teacher. The cooperating teacher provides purposeful coaching and mentoring, and the two pre-service teachers offer each other feedback, mentoring, and support (Leatham & Peterson, 2010b; Mau, 2013). As a Sub-RAC, we read articles (Goodnough, Osmond, Dibbon, Glassman, & Stevens, 2009; Leatham & Peterson, 2010a, b; Mau, 2013) to learn about the model. The research questions that guided the study are:

(1) What are the successes and challenges of implementation of the paired-placement model for clinical experiences at each different university?
(2) How do the successes and challenges of the paired-placement model compare across the various institutions involved in the study?
(3) What are attributes across the institutions that contributed to the successes of the paired-placement model?
(4) What are attributes across the institutions that contributed to the challenges of the paired-placement model?

One team implemented the model fall 2013 and reported to the other teams about its findings. Two additional teams used this information along with information from the literature to prepare mentor teachers and candidates for the experience Spring 2014. Teams also worked with their participants to adjust the model within their context utilizing PDSA cycles and monitored the process throughout the semester. Teams met via a conference call to discuss the results of the implementations and what they would do differently. During Fall 2014, teams built on these experiences to create professional development modules, syllabi, and measures. These materials were implemented during Spring 2015, utilizing suggested improvements from previous iterations. Teams implemented additional paired placements the following year: one during fall 2015, and six during spring semester 2016.

Through PDSA cycles and data collected from participants, we are learning much about the model. We have found that it allows teacher candidates to really focus on student learning and the craft of teaching. Teacher candidates and mentor teachers who have experienced this model believe that it benefits all of their growth in teaching as well as the students' growth in learning mathematics. They also

stated that the model has helped them to become more collaborative. Our goal is to continue to refine the workshops and syllabi so that they can be adapted to different contexts.

3.4 Conclusions and Next Steps

3.4.1 Progress

The MTE-Partnership has made significant strides in defining a common vision for secondary mathematics teacher preparation, identifying major problems impeding progress towards the vision, developing interventions to address those problems, and identifying measures to track progress. The Partnership's design has undergirded this process. NICs combine the disciplined inquiry of improvement science with the power of networking to accelerate improvement (Bryk et al., 2015). Use of improvement cycles by the RACs has helped to ensure interventions are not just changes, but improvements, and the network provides opportunities to test them across multiple contexts to see how they may need to be adapted to be most effective.

In the case of the Clinical Experiences RAC, all of the members have found the NIC to be helpful in improving their field experiences for secondary mathematics teachers and have seen growth in the secondary mathematics teacher candidates based on the changes that have been implemented. The challenge will be to see how well the tools work in other settings with people who were not engaged in the development process.

The full power of the MTE-Partnership NIC, however, can be seen in the breadth of the network it has established. First, given the number of institutions involved, the network provides the capacity to simultaneously address multiple problems of practice through its set of five RACs. Second, while each team generally only has the capacity to directly participate in the research of one or two RACs, the network provides the opportunity for teams to learn from the efforts of the other RACs in which they are not participating. Thus, the network provides a rich collection of resources to which Partnership teams can contribute and from which they can draw in improving their programs. No single institution could hope to address such a broad scope of improvement efforts.

3.4.2 Challenges and Next Steps

There are, however, significant challenges in harnessing the network to achieve the MTE-Partnership's goal of transforming secondary mathematics. First, there have been continuing challenges in maintaining the Partnership. As Martin and Gobstein

(2015) note, "There has sometimes been competition between building participant identification with the overall MTE-Partnership network and the individual RACs in which they participate" (p. 488). Maintaining effective leadership structures within and across the RACs require continuing attention, along with ensuring effective communications strategies.

Second, a growing concern for the MTE-Partnership is how to effectively manage the knowledge that is being generated by the RACs so that it is accessible by non-RAC teams. This requires maintaining an accessible repository of current materials as well as access to relevant training and support. In addition, teams using the interventions collect relevant data so that their experiences with the interventions can be incorporated into the knowledge that is being generated. Some RACs are beginning to experiment with how to best manage that process, but a more general approach across the Partnership is needed.

Third, teams may not have the needed resources and supports to simultaneously implement the findings across the multiple dimensions of improvement. Their initial focus was likely on one or two RACs in whose development they participated, and they may not have the personnel, time, or resources needed to incorporate findings that are emerging from the other RACs. This has led to the establishment of a new Partnership focus on developing approaches to support teams in establishing "strategic pathways for improvement" to manage the overall process of improvement. Teams will need to prioritize the improvements they can address based on their needs and available resources. This will also involve increasing awareness of and support for secondary mathematics teacher preparation, such as building "buy in" of institutional leaders, recruiting additional faculty members to participate in the effort, and shoring up relationship with school districts to better collaborate with field experiences. We are working to launch a new RAC to build approaches for addressing this challenge.

Finally, equity and social justice are highlighted within the *Guiding Principles* (MTE-Partnership, 2014) as well within the aims of each of the RACs. However, a survey of participants in the Partnership revealed that there is some concern about whether these issues are receiving consistent focus and attention. Thus, the planning team has formed a working group to explore how we can better ensure that equity and social justice issues are effectively interwoven into the fabric of the MTE-Partnership research efforts.

These challenges point to the need for the Partnership to continually change and evolve to meet changing circumstances and needs. Even the foundational documents need to be revisited. For example, the release of AMTE's (2017) *Standards for the Preparation of Teachers of Mathematics* raises the question of whether the *Guiding Principles* should be revisited to ensure that they adequately capture the best wisdom of the field. New priorities, such as the focus on program transformation and issues of equity and social justice, suggest that the Partnership's aim and driver diagram may need to be revisited to ensure they effectively capture the Partnership's most current thinking. The set of RACs has evolved over the past years, and it is likely that additional changes will occur as some RACs conclude their development of particular interventions, and as new needs are identified.

Moreover, new ways of interacting may be needed as the focus of teams moves beyond working with a RAC to improve some aspect of the program to overall program transformation.

3.4.3 Concluding Remarks

In conclusion, the NIC design has been very useful in framing the efforts of the MTE-Partnership to address significant problems related to the inadequate number of secondary mathematics teacher candidates who are prepared to support their students' success in mathematics. The Clinical Experiences RAC members have found working in a NIC to be beneficial in many ways, including identifying and solving problems of practice, collaborating on research projects and publications, and improving the relationships between school and district partners. We realized that even though our contexts may differ in subtle ways, we have enough issues and challenges in common to utilize PDSA cycles and common measures that could lead to transforming our programs. Indeed, we feel that the NIC model offers great potential in mobilizing networks of different types to address common problems in mathematics education and beyond.

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