Sharing and Building Resources to Equip and Empower Mathematics Teacher Educators

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Abstract

Members of the Clinical Experiences Research Action Cluster (CERAC) were asked at the 2018 Mathematics Teacher Education Partnership (MTE-Partnership) Conference to complete a survey indicating how their university mathematics teacher education (MTE) programs addressed the National Council of Teachers of Mathematics' (NCTM) Mathematical Teaching Practices mentioned in *Principles to Actions: Ensuring Mathematical Success for All* (NCTM, 2014) in methods courses. Survey results indicated four cross-cutting themes for how the Mathematical Teaching Practices were implemented in MTE programs. Resources were categorized into videos, classroom interactions, readings, and clinical practices. The resources used by the CERAC members to address the MTP and Association of Mathematics Teacher Education's (2017) *Standards for the Preparation of Teachers of Mathematics* (AMTE Standards) are shared in the conclusion.

Introduction

In the summer of 2018, the CERAC began a Plan-Do-Study-Act (PDSA) Cycle to examine how CERAC members integrated the eight researched-based effective Mathematical Teaching Practices espoused in NCTM's *Principles to Actions* (2014) within their university mathematics teacher preparation programs. Clinical Experiences is one of five RACs in the MTE-Partnership created in 2012 to strategically target issues in the shortage of strong mathematics teachers throughout the United States. The CERAC is committed to strengthening clinical experiences for math teacher candidates; attending to the Mathematical Teaching Practices in methods courses should be a goal of CERAC members. A Google form survey was created that asked CERAC members to describe how they attended to teacher candidates' development of the Mathematical Teaching Practices. As part of this PDSA Cycle, the researchers collected and organized the data according to each of the Mathematical Teaching Practices. The following paper seeks to share the study portion of the process and describe ways in which those in the CERAC, the larger MTE-Partnership network, and how other teacher educators may initialize institutional and program actionable changes. The research aligns with the MTE-Partnership's *Guiding Principles for Secondary Mathematics Teacher Preparation Programs* (2014), particularly Guiding Principle 1: Building a national consensus on what effective secondary mathematics teacher preparation programs need to do in order to develop teacher candidates who promote mathematical excellence in their future students, and Guiding Principle 4: Helping to organize the identification, development, and dissemination of resources supporting effective secondary mathematics teacher preparation programs.

Theoretical Framework for Effective Mathematics Teacher Preparation

In 2010, the National Governors Association and the Council of Chief State School Officers initiated a state-led effort to provide standardization of what college- and career-ready students should know and be able to do and released the *Common Core State Standards in Mathematics* (*CCSS-M*). The math standards included eight *Standards of Mathematical Practice* that students should experience during their K–12 learning of mathematics:

Smith, W. M., Callahan, K. M., Strayer, J. F., Jones, R. S., & Augustyn, L. C. (Eds.). (2019). *Proceedings of the eighth annual Mathematics Teacher Education Partnership conference*. Washington, DC: Association of Public and Land-grant Universities.

1. Make sense of problems and persevere in solving them.
2. Reason abstractly and quantitatively.
3. Construct viable arguments and critique the reasoning of others.
4. Model with mathematics.
5. Use appropriate tools strategically.
6. Attend to precision.
7. Look for and make use of structure.
8. Look for and express regularity in repeated reasoning. (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010)

The *Standards of Mathematical Practice* provide a balance between procedure and understanding in learning mathematics (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010). To support implementation of the *Standards of Mathematical Practice*, in 2014 NCTM published *Principles to Actions*, which included eight math teaching practices for effective teaching and learning. The Mathematical Teaching Practices provided a research-based framework for mathematics teachers to incorporate for effective student learning of mathematics. The Mathematical Teaching Practices are:

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. (NCTM, 2014)

Additionally, *Principles to Actions* included guiding principles for school mathematics that included teaching and learning, access and equity, curriculum, tools and technology, assessment, and professionalism, and a focus on productive beliefs versus unproductive beliefs about learning mathematics (NCTM, 2014).

To support university math teacher educators' focus on preparing well-prepared math teachers, the AMTE Standards guide what math teacher candidates should be able to know, understand, do, and the dispositions they should develop. Teacher candidates should develop pedagogical content knowledge that promotes active mathematical learning, and they should collaborate and learn from their peers. They *must* connect with their individual students and cultural contexts and support every student's opportunity to learn mathematics. Teacher candidates should nurture positive mathematical identities in every single student (AMTE, 2017).

The researchers volunteered to create a survey to determine how the Mathematical Teaching Practices were being addressed by the CERAC members. The importance of sharing how the *Standards of Mathematical Practice*, Mathematical Teaching Practices, and AMTE Standards are implemented will be beneficial information for the MTE-Partnership community and teaching practitioners.

Clinical Experiences Research Action Cluster

The CERAC is a consortium of 26 universities and their school partners engaged in developing clinical experience models designed to build candidates' facility with the Mathematical Teaching Practices and other equitable teaching strategies (Aguirre, Mayfield-Ingram, & Martin, 2013; AMTE, 2017) to promote secondary school students' success in achieving college- and career-ready standards. The CERAC is composed of three sub-RACs: Co-Planning/Co-Teaching (CPCT), Paired Placement, and Methods. The Methods sub-RAC has worked to engage MTEs by developing modules designed to promote the standards of mathematical practice, high-quality lesson planning, and high-quality feedback. The CPCT sub-RAC has worked to develop teacher candidates' implementation of co-planning and co-teaching strategies with the use of online modules that attend to the co-planning strategies: one plan/one assist, partner planning, one reflect/one plan, one plan/one react, parallel planning, and team planning (Cayton, Grady, Preston, & Sinicrope, 2016); and co-teaching strategies: one teach/one observe, one teach/one assist, station teaching, alternative teaching, parallel teaching, and team teaching (Bacharach, Heck, & Dahlberg, 2010). The Paired Placement sub-RAC focuses on implementing a student teaching approach where two pre-service teachers are paired with a single mentor teacher. This type of placement allows the mentor teacher to provide purposeful coaching and mentoring, and the two teacher candidates to offer each other feedback, mentoring, and support (Leatham & Peterson, 2010; Conway et al., 2018). Each of these sub-RACs have purposefully attended to the Mathematical Teaching Practices through data collection such as the Mathematics Classroom Observation Protocol for Practices (MCOP^2; Zelkowski & Gleason, 2016); teacher artifacts; teacher candidate journals; Mathematical Teaching Practices surveys; focus groups; and completer surveys. Both the MCOP^2 and the Mathematical Teaching Practices surveys specifically target high-leverage teaching practices in mathematics education, Mathematical Teaching Practices, and equitable instruction.

Methods

Researchers from the CERAC completing the PDSA Cycle began the instrument design in the 2018 Conference work sessions. During the work session, the researchers worked from a shared Google platform in order to design questions that would attend to each of the practices. After creation, the researchers shared the survey with the CERAC team to ensure that questions were targeting the need. Questions were revised based on feedback and dispersed to the CERAC team for completion. The final version of the survey (see Appendix) consisted of eight open-ended questions. The survey was emailed to 20 CERAC members, representing 18 institutions. Eleven CERAC members responded for a 55% return rate.

Researchers analyzing the data used cultural domain analysis (Bernard & Ryan, 2010) to understand how CERAC survey participants addressed each Mathematical Teaching Practice in methods coursework. Cultural domain analysis seeks to understand how people in a group, such as the MTE-Partnership CERAC members, think about and use knowledge across a list of things such as the Mathematical Teaching Practices. A free list matrix (Bernard & Ryan, 2010) was created to count the frequency and relationship between the Mathematical Teaching Practices. After initial review of the surveys, four cross-cutting types of tools were found to be used among the CERAC members: videos, classroom interactions, readings, and clinical practices. These tools were then cross-analyzed to find patterns of association and dissociation using Table 1.

Results

A total of 11 institutions from the CERAC participated in completing the survey. Participants taking the survey may have mentioned multiple tools they use in their program to develop teacher candidates' understanding, development, and use of the Mathematical Teaching Practices. For this reason, the totals in this paper should be examined with a collective CERAC lens rather than as individual participants. A collective summary of how these 11 institutions responded is presented in Table 1.

Table 1
Cross-Cutting Types of Tools

	MTP1[a]	MTP2	MTP3	MTP4	MTP5	MTP6	MTP7	MTP8	Total
Readings	6 (.3)	5 (.19)	3 (.14)	5 (.23)	8 (.22)	7 (.39)	2 (.14)	5 (.29)	**41 (.23)**
Videos	4 (.2)	2 (.07)	2 (.1)	1 (.05)	2 (.05)	1 (.06)	2 (.14)	2 (.12)	**16 (.09)**
Classroom Interactions	1 (.05)	17 (.63)	13 (.62)	8 (.36)	13 (.35)	9 (.5)	9 (.64)	6 (.35)	**76 (.43)**
Clinical Practice	9 (.45)	3 (.11)	3 (.14)	8 (.36)	14 (.38)	1 (.06)	1(.07)	4 (.24)	**43 (.24)**
Total	**20**	**27**	**21**	**22**	**37**	**18**	**14**	**17**	**176**

[a] MTP is Mathematical Teaching Practices, from NCTM (2014).

Collectively, institutional responses were coded as videos, classroom interactions, readings, and clinical practices to produce a general organization of how the MTE-Partnership has addressed the Mathematical Teaching Practices. Frequencies in Table 1 represent the number of occurrences an MTE-Partnership institution used this tool to develop a Mathematical Teaching Practice. Proportions in parenthesis represent the proportion of occurrences a MTE-Partnership institution described a tool in developing each an individual Mathematical Teaching Practice. A brief review of the proportions may provide evidence for either further development of resources for a particular Mathematical Teaching Practice or a need for curriculum revision in partner institutions. The following four sections highlight responses that were categorized as each tool.

Videos

Participants in the CERAC noted a number of resources that were used that related to watching and reflecting on videos of teaching. These digital resources were described in ways that also connected with classroom interactions. However, the researchers decided to report digital resources separate from classroom interactions for readers' ease of implementation. As follows is a description of a survey response describing the use of a digital tool or video in a math methods course:

> Teacher candidates have previously worked the "Bike and Truck" task from the *Principles to Actions* toolkit lesson: Bike and Truck Task - The Case of Shalonda Shackelford. Teacher candidates watch video clip 1 in class, which is followed up with a "Think-INK-Pair-Share" formative assessment about observations from the first video clip. Teacher candidates watch video clip 2 in class, which is followed up with a Think-INK-Pair-Share on how Ms. Shackelford facilitate meaningful mathematical discourse in her classroom.

Other video sources mentioned include insidemathematics.org, ATLAS (https://atlas.nbpts.org/), the *Principles to Actions* toolkit, robertkaplinsky.com, and personally recorded videos for self-reflection. The use of technology to effectively notice and train future teachers is becoming an invaluable resource for teacher educators. Further analysis on the use of videos in teacher preparation follows in this paper.

Classroom Interactions

A number of different descriptions were categorized as classroom interactions from participant responses and represented the largest percent (43) of tools used to develop teacher candidates' development, understanding, and use of Mathematical Teaching Practices. A participant stated,

> To help teacher candidates make connections between physical, symbolic, verbal, graphical representations, tasks are carefully selected to provide opportunities to solve them in multiple ways. Additionally, teacher candidates are required to purchase a manipulative kit for their methods course.

A statement such as this directed toward multiple representations was categorized as classroom interactions. Similarly, respondents also described activities they performed in class to highlight MT Mathematical Teaching Practices such as facilitating meaningful mathematical discourse:

> Solving problems in teams requires meaningful mathematical discourse between team members. I also model real problems with mathematics every time I can during regular lectures. The courses I teach lend themselves to it wonderfully. Each small group must report out to the class. One member of each group will be chosen at random to present. This ensures that all members make sure that all other members are ready. Then, they use large-group discussion to compare and contrast group-solution strategies.

Respondents described activities used in class such as discussions, mathematical tasks, reflections, sorting activities, course assignments, assessment using the National Assessment of Educational Progress (https://nces.ed.gov/nationsreportcard), Advanced Placement Central (https://apcentral.collegeboard.org/) and MARS resources (https://mars.nasa.gov/participate/marsforeducators/), and teaching demonstrations by teacher candidates. Further analysis on how classroom interactions play a part in teacher preparation programs follows in the analysis section of this paper.

Readings

Resources were described in surveys that require teacher candidates to read materials in different ways. One participant stated,

> The math books I use in my two courses have a variety of problems suitable for promoting these goals. What I do is assign some of these problems for solving in class by groups of 3 or 4 students, and then have team members explain their solutions and conclusions.

Sometimes these descriptions intersected with other categories such as classroom interactions of discourse and reflection. Participants from the CERAC discussed the use of NCTM's (2014) *Principles to Actions*; *5 Practices for Orchestrating Productive Discussions* (Smith & Stein, 2011); Smith and Stein's "Creating Mathematical Tasks" (1998); EdTPA handbooks; *CCSS-M* Learning Progressions; estimation180.com; Pesek and Kirshner (2000); *Mathematical Mindsets: Unleashing Students' Potential Through Creative Math, Inspiring Messages and Innovative Teaching* (Boaler, 2015); Bass and Ball (2015); *Questioning Our Patterns of Questioning* (Herbal-Eisenmann & Breyfogle, 2005); and *Decoding the Common Core* (Dillon, Martin, Conway, & Strutchens, 2017). Readings are a powerful component of a mathematics teacher preparation program, but used alone they are not as effective. Analysis later provides structure for teacher preparation programs to consider professional reading in the success of their programs. However, clinical experiences are essential components of a teacher preparation program that should not be ignored.

Clinical Practice

Descriptions of teacher educator practice related to clinical experiences was the second-most described method to increase teacher candidates' understanding and use of Mathematical Teaching Practices. Descriptions from survey results categorized as clinical experiences related to debriefing sessions after teaching, lesson plan construction and implementation, task reflections related to portfolios such as EdTPA, modules, and field-based observation rubrics such as the MCOP^2 (Zelkowski & Gleason, 2016). Though clinical experiences are one of the most powerful tools for developing teacher candidates, they should be integrated with other tools to develop their understanding, which is described in the next section. One participant stated,

> The MCOP^2 does this for us. The requirement to engage students by teacher candidates during implemented lessons, the items that require teacher candidates to facilitate discourse and items that specifically assess student discourse make this evident. The quality of the discourse is addressed by planning two days in advance and receiving feedback prior to implementation.

As this participant described the clinical experience, it is important to highlight the connection of the clinical experience to feedback on the Mathematical Teaching Practices for analysis purposes.

Table 2

Innovation Configuration Tools Mapping

	Level 1	**Level 2**	**Level 3**
MTP1[a]: Goals to Focus Learning	25%	55%	20%
MTP2: Tasks that Promote Reasoning and P/S	58%	37%	7%
MTP3: Use and Connect Representations	38%	43%	19%
MTP4: Facilitate Meaningful Discourse	23%	50%	27%
MTP5: Pose Purposeful Questions	22%	56%	22%
MTP6: Building Procedural Fluency from Conceptual Understanding	33%	56%	11%
MTP7: Supporting Productive Struggle	14%	79%	7%
MTP8: Elicit and Use Evidence of Thinking	22%	60%	18%

[a] MTP is Mathematical Teaching Practices, from NCTM (2014).

Analysis

The tools used across survey participants suggested analysis that disaggregated instructional practices and teacher candidate experiences that are used throughout programs that promote the use of Mathematical Teaching Practices. In addition, these tools suggest the extent to which teacher educators provide opportunities for teacher candidates to apply Mathematical Teaching Practices in ways that provide explicit feedback and sustained implementation and support to ensure fidelity. For this reason, an innovation configuration was used to analyze the partnerships methodologies for program evaluation (Hall & Hord, 1987; Roy & Hord, 2004). An innovation configuration can be used to promote the implementation of evidence-based instructional practices in teacher education programs. Innovation configurations can be designed to assess teacher education programs as to the extent to which evidence based practices are taught, observed, and applied along particular strategic practices (Hall & Hord, 1987; Roy & Hord, 2004).

Researchers adopted the innovation configurations suggested by the Collaboration for Effective Educator Development, Accountability and Reform (CEEDAR) Center (http://ceedar.education.ufl.edu), an organization committed to improving the implementation of evidence-based instructional practices in teacher preparation programs. This group has suggested mapping tools and methods for addressing culturally relevant pedagogy and other teacher educational goals across three levels. Level one contains readings, lectures, presentations, discussions, models, quizzes, tests, and demonstrations of the Mathematical Teaching Practices. Level two includes observations, projects, case studies, reflective assignments not related to teacher candidates' teaching, and lesson plans. Level three was coded as K–12 student tutoring, small-group teaching, whole-group instruction, and tasks such as reflections, related to these experiences. Table 2 summarizes the analysis using this innovation configuration for each Mathematical Teaching Practice.

Limitations, Implications, and Suggestions

Results and analysis from this survey provide initial evidence that each Mathematical Teaching Practice is being addressed at varying levels across the MTE-Partnership network, and showing some general consistency in levels for each Mathematical Teaching Practice. Generally, the majority of instruction related to Mathematical Teaching Practices is at level 2 in CERAC survey participants. It is hypothesized that this is true based on the time spent in courses developing understanding of Mathematical Teaching Practices before participating in clinical experiences where these practices are expected to be implemented in with K–12 students. In addition, the large percent of level two IC codes is likely to correlate with the partnerships connection with alternative uses of assessment to gauge student development of Mathematical Teaching Practices. This first PDSA Cycle by the CERAC focused on the Mathematical Teaching Practices serves as a tool for other programs to critically examine their own strengths, weaknesses, and development of students' Mathematical Teaching Practices across institutional course progressions.

However, findings must be analyzed with caution. The current survey and analysis was administered and completed voluntarily by CERAC members. Participant involvement did not require deep synthesis or reflection by teacher educators. During analysis, the researchers noted shortened responses by participants as they described how their programs addressed the Mathematical Teaching Practices. Because of this fact evidenced in the data, it is advised for the MTE-Partnership to consider a broader survey administration with potential stipends for adequate survey completion.

An important component of this survey administration was the sample, which presents potential limitations, implications, and suggestions for future CERAC and MTE-Partnership research. The surveys' limited sample of CERAC participants makes findings difficult to generalize to other MTE-Partnership institutions. However, results provided opportunity for reflection by the network as a whole and a potential framework to begin tracking materials being implemented across the partnership. Using the framework presented in this paper or a similar one allows for the partnership to conceptualize their work and its progression of development inside and outside RACs for continued improvement.

Lastly, the innovation configuration framework provided in these proceedings can serve as a guide for other partner schools to critically examine their program goals toward teaching Mathematical Teaching Practices with fidelity. As programs begin to analyze their own student progressions, it is advised for the partner schools to attend to the level of understanding and demonstration of the Mathematical Teaching Practices at each innovation configuration level as students develop in their programs. A recommendation for programs using this innovation configuration for program improvement are encouraged to track levels of Mathematical Teaching Practice implementation as they relate to each course and their progression through their mathematical programs. Earlier courses would be expected to have more level one and two instances of innovative practices, while later courses would be expected to have more at levels two and three—largely because students need to know about

Mathematical Teaching Practices before being asked to implement them in experiences. It would be advised for program directors to utilize this innovation configuration framework to identify areas of need in courses by having discourse with the instructors and/or reviewing course syllabi.

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Appendix

MTE-Partnership Clinical Practices Implementation of Mathematics Teaching Practices from *Principles to Actions* Survey

1. What is your name?

2. How are you implementing the Mathematics Teaching Practice: Establish Mathematics Goals to Focus Learning with your PSTs?

3. How are you implementing the Mathematics Teaching Practice: Implement Tasks That Promote Reasoning and Problem Solving with your PSTs?

4. How are you implementing the Mathematics Teaching Practice: Use and Connect Mathematical Representations with your PSTs?

5. How are you implementing the Mathematics Teaching Practice: Facilitate Meaningful Mathematical Discourse with your PSTs?

6. How are you implementing the Mathematics Teaching Practice: Pose Purposeful Questions with your PSTs?

7. How are you implementing the Mathematics Teaching Practice: Build Procedural Fluency to Promote Conceptual Understanding with your PSTs?

8. How are you implementing the Mathematics Teaching Practice: Support Productive Struggle with your PSTs?

9. How are you implementing the Mathematics Teaching Practice: Elicit and Use Evidence of Student Thinking with your PSTs?