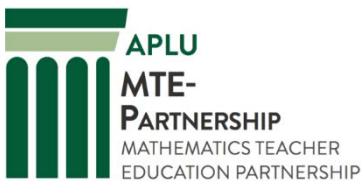

**PROCEEDINGS OF THE SEVENTH
ANNUAL MATHEMATICS TEACHER
EDUCATION PARTNERSHIP CONFERENCE**

**THE MTE-PARTNERSHIP:
TRANSFORMATION. EQUITY. LEADERSHIP.**

Wendy M. Smith
Brian R. Lawler
Jeremy F. Strayer
and
Lindsay Augustyn
(Editors)



June 24–26, 2018
Denver, CO
United States

Proceedings of the Seventh Annual Mathematics Teacher Education Partnership Conference

Edited by Wendy M. Smith, Brian R. Lawler, Jeremy F. Strayer, and Lindsay Augustyn

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Preface

These proceedings are a written record of the presentations and papers presented at the Seventh Annual Mathematics Teacher Education Partnership Conference held in Denver, June 24–26, 2018. The theme for the conference was “The MTE-Partnership: Transformation. Equity. Leadership.” We are pleased to present these Proceedings as a resource for the mathematics and mathematics education community.

www.mte-partnership.org

¹ Robert N. Ronau participated as a member of the MTE-Partnership Planning Team while serving at the National Science Foundation. Any opinion, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

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INTRODUCTION

The Seventh Annual MTE-Partnership Conference: Equity, Transformation, Leadership

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MTE-Partnership Co-Directors

The Mathematics Teacher Education Partnership (MTE-Partnership) was formed by the Association of Public and Land-grant Universities (APLU) in 2012 to address a major problem in secondary mathematics teacher preparation: a lack of secondary mathematics teachers entering the profession who are well prepared to ensure their students can meet rigorous state mathematics standards for college- and career-readiness, as described in the Common Core State Standards for Mathematics (CCSS-M; Common Core State Standards Initiative, 2010) and other documents. This consortium of more than 90 universities and more than 100 school systems has a common goal of transforming secondary mathematics teacher preparation using the Networked Improvement Community (NIC) design (Bryk et al., 2015). This paper will provide a brief overview of the MTE-Partnership, its evolution over the past several years, and the particular goals for the Seventh Annual Conference held in June 2018.

An Overview of the MTE-Partnership

The initial concept for the Partnership was formed at the APLU's 2011 Annual Conference of the Science and Mathematics Teaching Imperative, which focused on how higher education might respond to the just-released CCSS-M, including necessary changes in teacher preparation. 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 40 partnership teams across 31 states in the United States (see Figure 1).

About a year after its formation, the MTE-Partnership adopted the NIC model developed and used by the Carnegie Foundation for the Advancement of Teaching. The planning team had identified several design challenges 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. NICs are distinguished by four essential characteristics (Bryk, Gomez, Brunow, & LeMahieu, 2015); each characteristic is described as follows, along with a discussion of how the Partnership continues to address that characteristic.

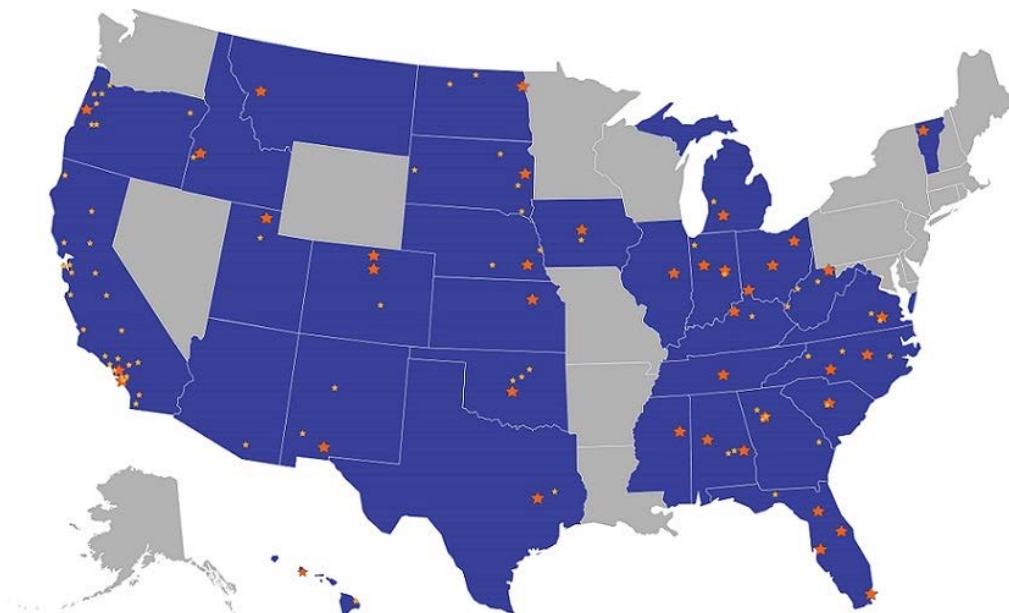


Figure 1. Participation in the MTE-Partnership. Large stars represent lead institutions for a team, and small stars represent other participating universities and colleges.

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. Note that the improvement target was set through a collaborative process of collecting data from the individual teams and programs. This characteristic remains central to the success of the Partnership; as emphasized by the authors in the opening remarks to the 2018 Conference, “We will not make progress if we are not aiming in the same direction!” While many solutions might be proposed by members of the Partnership, the aim provides a litmus test of whether those solutions should be pursued.

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 MTE-Partnership, which is reflected in its Guiding Principles for Secondary Mathematics Teacher Preparation. This document then formed the basis 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 Figure 2, these problems are restated in the positive as primary drivers, the Partnership’s main areas of influence necessary to promote movement toward achieving the aim (Bryk et al., 2015), which is given in the left-most column. 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). Again, as emphasized by the authors in their opening remarks, “You cannot improve what you do not understand”—this process must be ongoing.

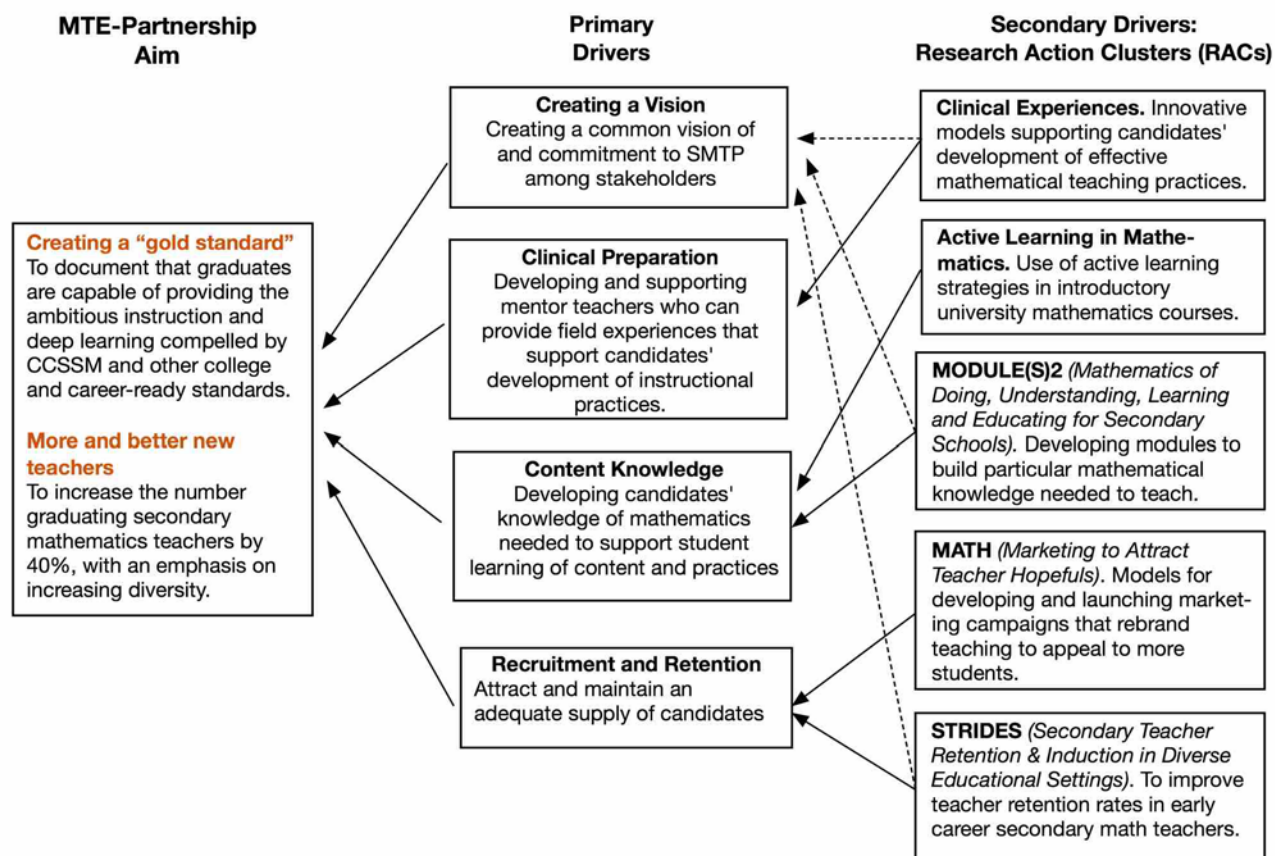


Figure 2. The MTE-Partnership driver diagram (Martin & Gobstein, 2016).

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, Plan-Do-Study-Act (PDSA) cycles (see Figure 3) are used to iteratively prototype, test, and refine interventions; use of PDSA cycles 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 Figure 2. Further discussion of their current work is given in the Research Action Cluster Reports section of the proceedings. Each RAC has developed its own aim statement and driver diagram and undertakes PDSA cycles to guide improvement efforts in alignment with its driver diagram. In some sense, the RACs may be considered sub-NICs. The RACs have continued to refine their aims and driver diagrams as needed over the years. As the authors emphasized in the opening session, based on remarks often made by their colleagues at the Carnegie Foundation, "Not every change is an improvement." It is all too easy to engage in devising solutions to problems, but without a commitment to evidence-based decision-making, we are unlikely to make progress toward our aim.

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 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

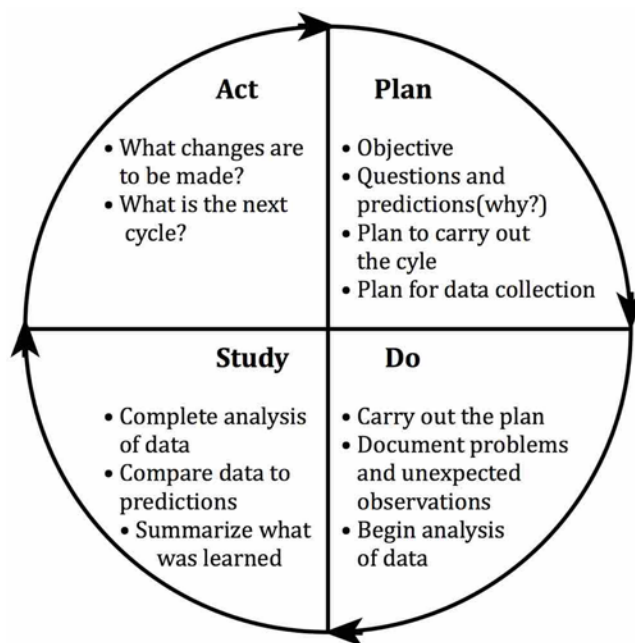


Figure 3. The Plan-Do-Study-Act (PDSA) Cycle. (Adapted from Langley, Moen, Nolan, Nolan, Norman, & Provost, 2009)

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. The networked organization further 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. As stated in the opening remarks, “We are stronger together.”

The Role of the Annual Conferences

Over the seven years of the MTE-Partnership, the annual conferences have served as important landmarks where many of those active with the Partnership gather together to reflect on the progress that has been made throughout the past year and set forth plans for the coming year. A brief outline of the previous six conferences follows, following the developmental trajectory of the MTE-Partnership; a more detailed account can be found in the introduction to the Proceedings of the Fifth Annual MTE-Partnership Conference (Martin & Gobstein, 2016).

2012 Conference: The first conference, held in April 2012, focused on creating an initial draft of guiding principles for the MTE-Partnership, which led to the Guiding Principles for Secondary Mathematics Teacher Preparation, since updated in 2014, the central organizing document for the Partnership described previously. A first attempt was also made at identifying central challenges in meeting the guiding principles; follow-up work led to the development of the aforementioned four primary drivers.

2013 Conference: The second conference focused on learning more about the NIC design, which had been adopted following the 2012 conference, and developing the problem space for the Partnership in alignment with that design. Initial concepts were written for a set of 13 RACs, which were later narrowed down to an initial set of five that were launched in the fall following the conference. Teams were invited to join the RACs, and an initial boot camp organized by representatives of the Carnegie Foundation was convened in the fall following the

conference to initiate their work. The Carnegie Foundation played a key advisory role throughout the launch of the RACs.

2014 Conference: The third conference was focused on the work of the RACs. RAC members met in small groups to review their initial work in forming an aim and driver diagrams and to begin planning specific improvement efforts to be undertaken in the coming year using PDSA cycles in which evidence would be gathered to guide their continued development and refinement. Additional sessions focused on increasing understanding of the NIC design and exploring issues related to secondary mathematics teacher preparation. The RACs continued their work throughout the following year.

2015 Conference: The fourth conference continued a primary focus on accelerating the work of the RACs. A new RAC on improving the retention of program graduates in the profession was also launched, replacing an earlier RAC. This conference saw the incorporation of all 22 campuses of the California State University system that offer teacher preparation, greatly increasing the capacity of the MTE-Partnership. The 2015 conference also introduced an emerging emphasis on program transformation, reflecting the challenges programs face in moving beyond making changes based on the one or two RACs in which they are actively engaged, to aggregating the findings of multiple RACs to undertake the broad-scale changes needed to ensure both the necessary quantity and quality of secondary mathematics teacher candidates.

2016 Conference: The work in the RACs was again the focal point of the 2016 conference. A newly formed working group on program transformation presented a panel discussion of issues related to transformational change at the conference and continued its work throughout the following year. In addition, a new focus on equity and social justice was launched; while these issues are embedded in the Guiding Principles and in the work of many of the RACs, members of the planning team noted that this is not visibly a part of the Partnership aim or drivers. A work session was held at the conference to discuss how to make equity and social justice a more explicit focus of the Partnership. In addition, a series of refereed brief research reports were included in the conference to enhance the sharing of ongoing work across the partnership. For the first time, Conference Proceedings (Lawler, Ronau, & Mohr-Schroeder, 2016) were released to provide an accessible record of the work of the Partnership at the Conference and throughout the past year.

2017 Conference: The overall trajectory of work by the MTE-Partnership continued at the 2017 conference. The work of the RACs was highlighted along the themes of program transformation and equity and social justice. The theme of program transformation was addressed in a keynote by Jennifer Russell, fellow at the Carnegie Foundation for the Advancement of Teaching, who discussed the power of networks for program improvement, and a working dinner organized by the Transformations Working Group. A panel discussion by Partnership participants addressed various aspects of equity and social justice related to secondary mathematics teacher preparation; Nicole Joseph, noted scholar on issues of equity, served as a reactant to the panel and to the conference at its conclusion. A new working group of equity and social justice was launched prior to the conference, and work sessions were organized by both the Transformations Working Group and the Equity and Social Justice (ESJ) Working Group. The series of refereed research reports was expanded, again appearing in a Conference Proceedings (Smith, Lawler, Bowers, & Augustyn, 2017).

Goals of the 2018 Conference

The Seventh Annual MTE-Partnership Conference had four primary goals to continue progress toward the Partnership aim, building on the work done in previous years. Each goal is discussed in turn, along with how the structure of the conference supported that goal.

Partnership/institutional teams will plan next steps in transforming their programs: The importance of better understanding program transformation has been repeatedly emphasized by the planning committee and in surveys of the MTE-Partnership teams. A number of elements of the 2018 conference supported this goal, including a keynote in which Susan Elrod, noted author in the area of institutional change in the science, technology, engineering, and mathematics (STEM) disciplines (cf. Elrod & Kezar, 2016), interacted with Marilyn Strutchens, noted scholar in issues related to equity in mathematics education, on the two conference themes and their interaction. A panel of representatives from five Partnership teams discussed aspects of program transformation Monday morning. The Transformations Working Group organized a discussion session Monday afternoon. A series of posters by the RACs and Working Groups presented in the opening session and available for viewing across the conference provided teams with information on other areas of work that might be of use.

The RACs will continue their work to improve aspects of secondary mathematics teacher preparation, including considering how they share their work in order to contribute to additional teams' transformational efforts and to the knowledge of the field: This goal is central to the work of the MTE-Partnership, given that the major work of improvement happens within the RACs. The RACs spent more than nine hours working at the conference, central to their goal in progressing toward their respective aims. A special emphasis was placed on how they might begin to disseminate their work, both within the Partnership to support teams' transformation work and to external audiences. RACs were particularly encouraged to consider how they might organize their ongoing work, given that external funding for face-to-face convenings is coming to an end. Updates on their progress can be found in the Research Action Cluster Reports section of these proceedings.

The Partnership as a whole will grow its sense of joint purpose and identity as a NIC-supporting program transformation: It is critical that the Partnership maintain a sense of common purpose and identity, since participants may tend to focus on the problems that interest them, particularly the work of the RACs in which they are involved (Martin & Gobstein, 2015). While the RACs may be their specific focus for participation, there is much to be gained by emphasizing the broader structure of the Partnership, including learning from and with the other RACs and considering the more general context for the work of the RACs. The project co-directors emphasized the defining characteristics of the Partnership as presented in the previous section, emphasizing the importance of those characteristics for the continuing success of the Partnership. Brief research reports were again included to build understanding of the work going on across the partnership. Finally, conference reactants were asked to consider cross-RAC themes, as well as recommendations for possible new directions MTE-Partnership might pursue in advancing its national profile.

Specific focus on equity and social justice will be included throughout the proceedings: The theme of equity and social justice was threaded throughout the conference. Many members of the ESJ Working Group are also members of the RACs and were charged with helping foreground relevant issues. The Working Group again organized a working session Monday afternoon to discuss how equity and social justice can be better addressed. As discussed previously, one of the speakers for the working dinner specifically addressed equity and social justice, and the reactants were encouraged to include attention to equity and social justice in their remarks.

A new feature was introduced to reflections across the conference, particularly during the plenary sessions: participants were asked to post their thoughts on Padlet. Prompts in the working dinner encouraged them to reflect on the themes of the conference, program transformation and equity and social, and opportunities they identified for making progress. They were also asked to reflect on the panel discussion on program transformation and then identify new opportunities for progress. Reflections on the conference reactants were followed by final additions to opportunities for progress. At the conclusion of the closing session, participants were asked to identify specific actions they would undertake by the end of August and by the end of September. While

their posts were anonymous, the intention was that posting their plans might provide a level of accountability in carrying out those plans.

Final Reflection

In some sense, the 2018 MTE-Partnership conference consolidated the progress of the past seven years and will serve as a launching pad for the coming years. This conference, along with the preceding six conferences, was found very productive by the participants, as can be clearly seen in the evaluations that have been conducted each year. In thinking across the conference as a whole, participants reported the following *for each of the seven annual conferences*:

- 94% or more agreed that the conference had clear goals (100% in 2017 and 2018).
- 97% or more agreed that progress was made in achieving conference goals (100% in 2017 and 2018).
- 92% or more agreed that the conference was informative and worthwhile (100% in 2017 and 2018).
- 100% agreed that the interactions with other participants were useful and productive for all seven conferences.
- 94% or more agreed that the conference was a good use of their time (100% in 2017 and 2018).
- 98% or more expressed interest in participating in future MTE-Partnership events (100% in 2017 and 2018).

Many of their concluding remarks, both on the Padlet discussion space organized across the conference and in the subsequent conference evaluation, suggest that the themes of the conference (“Transformation. Equity. Leadership.”) were realized. As the Partnership moves beyond its existing sources of external funding, which have supported its infrastructure over the past years, the commitment and creativity of Partnership participants will be essential in building on the trajectory established over the past seven years.

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Overview of the Conference

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The Seventh Annual Mathematics Teacher Education Partnership (MTE-Partnership) Conference was held at Magnolia Hotel in Denver, CO, from June 24–26, 2018. With 99 registrants from 32 of the 39 MTE-Partnership teams, the theme for this year’s conference was “The MTE-Partnership at Six Years: Transformation. Equity. Leadership.”

In support of the partnership aim, the goals for the 2018 annual conference were:

- The Partnership/institutional teams would plan next steps in transforming their programs.
- The Research Action Clusters (RACs) would continue their work, including considering how they share their work, in order to contribute to additional teams’ transformational efforts.
- The Partnership as a whole would grow its sense of joint purpose and identity as a networked improvement community supporting program transformation.
- A specific focus on equity and social justice would be included throughout the proceedings.

The MTE-Partnership conference opened on Sunday afternoon, June 24, with a brief welcome, followed by lightning-round poster sessions. Posters were shared by each RAC and Working Groups. The lightning-round format allowed participants new to the MTE-Partnership to learn more about each RAC, before the afternoon moved into RAC work time (see the RAC section of these proceedings for what each RAC worked on during this year’s conference). The RACs worked throughout the conference: Sunday afternoon, Monday morning, Monday afternoon, and Tuesday morning.

During the Sunday dinner hour, Susan Elrod and Marilyn Strutchens each gave brief talks about equity in program transformation. Their individual talks (in the Opening Address section of these proceedings) were followed by a question-and-answer period. Elrod highlighted the cyclical process of program transformation and used a river analogy: You can enter at any point and may encounter rapids and eddies. Strutchens followed this with a focus on equity. It is crucial that mathematics teacher educators keep equity at the heart of improvement initiatives in order to achieve program transformations aligned with the Association of Mathematics Teacher Educators (2017) Standards for Preparing Teachers of Mathematics. During the question-and-answer period, Elrod encouraged programs to disaggregate their student outcomes data by Pell-eligibility; she found this was an explanatory variable in some of her research and urged participants to consider how to better support such students. Elrod also encouraged local partnership teams to better include deans and other administrators in their work; support from administrators can provide necessary resources for change efforts. When asked how to handle positional leaders who announce initiatives but then do not support change efforts, Elrod suggested working around such people, so that they cannot inhibit change efforts. Strutchens was asked how we as a field can achieve true equity; she replied,

I think it takes more than a few people talking about equity issues in order to change systems... We can’t expect just the people who do research on equity to change things; it has to be all of us working together to change things.

The system didn’t get to be inequitable in a day nor due to a single person, so it will take all of us working together over a longer period of time to achieve more equitable student outcomes. Finally, Elrod advised potential change

agents to “build an army”—recruit a large number of people to join in the common vision and work toward common goals:

You have to enlist others, and get people working with you. I think that’s especially important because somebody moves on to be department chair, somebody goes on sabbatical, somebody takes a leave of absence, somebody leaves and takes another job; there’s always change and so the way you can buffer yourselves against change is to make sure you have enough of an army of people with you. One of the challenges I think we all face is, how do we get the army, how do we convince others of our passion? I think it’s important for everyone to get outside of yourselves just a little bit and try to learn about what others care about or are interested in and then connect your passion to that. Find common ground to enlist others and then you will hold each other up and form a larger community of people who can really keep the momentum going and stable.

Sustainable change efforts take lots of ongoing work, with intentional plans to account for turnover in personnel, particularly those in leadership positions.

On Monday, June 27, the day began with a plenary session that featured five panelists discussing transformation efforts at their local partnerships. The panelists talks are included in these proceedings: Alyson Lischka (Middle Tennessee State University), Jeremy Zelkowski (University of Alabama), Ruthmae Sears (University of South Florida), Mark Ellis (California State University, Fullerton), and Wendy Smith (University of Nebraska-Lincoln). Monday afternoon and Tuesday morning each included two sets of concurrent presentations by MTE-Partnership members, in 19 different presentations. Each of these presentations (abstract and/or full article) are included in these proceedings. Finally, Tuesday’s closing session featured reactions by Michael Steele (University of Wisconsin-Milwaukee and incoming president of the Association of Mathematics Teacher Educators) and Cathy Martin (Director of Mathematics in Denver Public Schools and National Council of Teachers of Mathematics Board member). These reflections are in the closing section of these proceedings. Both the Transformations Working Group and Equity and Social Justice Working Group met on Monday in the late afternoon. These discussion sessions moved the work forward while also sharing with new participants the history of these working groups. A summary of each working group discussion session is in these proceedings.

Overall, evaluations of the 2018 MTE-Partnership Conference were extremely positive. One hundred percent of respondents plan to attend future MTE-Partnership events; over 90 percent of respondents found the 2018 conference to be a good use of their time, with clear goals, and useful and productive interactions with other participants. MTE-Partnership attendees agreed it is important to have common measures and benchmarks across the partnership and approve of the two major areas of focus for the future: pathways to program transformation and equity and social justice.

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OPENING ADDRESS

Equity in Program Transformation Part 1

Susan Elrod, University of Wisconsin-Whitewater, elrods@uww.edu

Thank you for inviting me to join you for this conference. I would like to talk just a little bit about a model that we developed in a project with 11 institutions, all trying to do STEM reform. The model isn't specific to math, necessarily, and it is focused at the institutional level as the participating teams were working on projects that went beyond a course, a program, or a department. In general, if you are trying to affect something beyond a course, program, or department, there are impacts on and involvement of other departments or divisions at your university, such as Students Affairs, or policies like promotion in tenure standards that must articulate department standards but also meet university expectations. At the time we initiated the project, people were struggling with how to get something more systemic or institutional launched and sustained.

I started this project with my colleague, Adrianna Kezar, about five or six years ago, and we enlisted 11 universities in California, in public and private, research, comprehensive, and liberal arts institutions. We asked them to embark on an institutional change project on their campuses and then we worked with them through that project. In the end, in a very kind of grassroots way, we looked back and asked, "What would have been helpful to you?" And that's essentially where the model in Figure 1 came from.

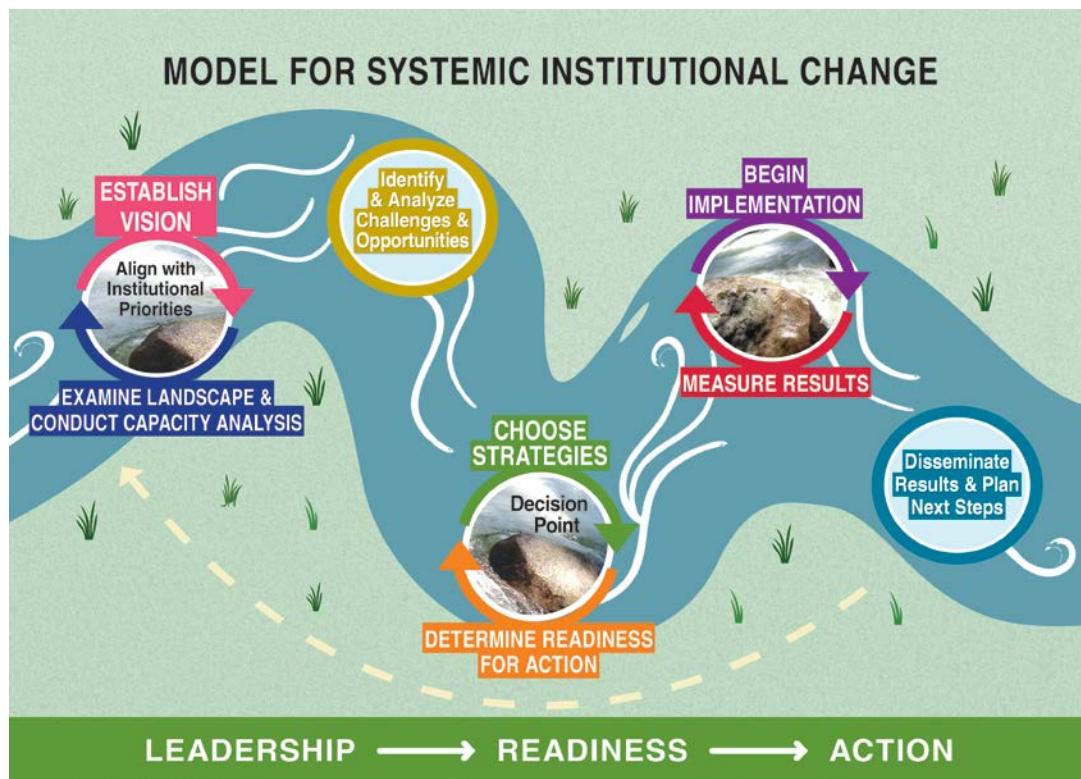


Figure 1. Systemic Institutional Change Model. (Elrod & Kezar, 2016)

We call it the Systemic Institutional Change Model and use a river analogy to represent it (we also refer to it as the River Model). The reason we choose a river to represent this model is because change is not linear, it's not simple, you can run into rapids, there might be rocks in the river, which are shown in three places in the image. Where you see the arrows going around them is where you might eddy out or eddy around and spend some time. These are places where our project teams spent time, going around and around until they figured it out. Also, if you are rafting or kayaking down a river, you could get out, take your raft or kayak and get out at any point. When you reach the end, you can get out and hike back to the beginning and raft down over again. You can also enter at any point. So, we thought the river was a nice analogy. But optimally, you really should start at the far-left side of this model, upstream. It is generally easier to navigate a river by going with the current!

I know all of you are immersed in various kinds of projects, and you probably already know that it's important to start with a vision, which is the first step in the model, but also, it's not just your individual vision, but it is your shared vision with the others in your project. It is important that you have taken the time with your colleagues and whomever it is that you are working with to articulate a shared vision in a common language to which everyone agrees and understands. How many of you feel like you have a shared vision with your colleagues? It turns out, not only is this the most important place to start, but it is the most difficult place to start because your idea about what should be accomplished is probably very different from your colleagues'. But if you are ever going get it together and get something done, you have to get on the same page. I recommend that you spend the time to articulate it in writing. Write it down, share your words with one another, and come up with that vision. And then you can develop specific goals, strategies, and tactics from there.

It is also important to think about how connected, or not, that vision is to institutional, strategic goals, priorities, or plans. All of you are at colleges or universities; how many of you have read your university's strategic plan? This is especially important if you are going to enlist the support of your president, your provost, or dean. As a provost, my main priorities are those that are attached to a goal in our university's strategic plan because those goals are, in large part, what I am held accountable for. So, if you come to me for funding requests, I'm going to ask, "How does this fit into the strategic plan?" Then you have to convince me with a solid rationale and plan. The next step of creating a vision has to do with understanding your current data landscape to frame the context for the problem you are trying to solve. What do you know about the students you are trying to impact? How many of you feel like you have a good handle on the data that is related to the goals you're trying to accomplish in your project? It could be course pass or failure rates, student progression, student retention, graduation rates. There could be all kinds of other data that might be relevant, like data from placement tests and other placement systems or the PRAXIS performance assessment for teachers.

In thinking about data, also think about disaggregating the data by different ethnic groups, gender, and other demographic elements. How many of you are disaggregating data by Pell eligibility? Here is a story about using Pell eligibility as a data element. Many institutions are focusing a lot on underrepresented minority student retention and graduation so are disaggregating their data by those types of categories. By adding a variable, like Pell eligibility, you may come to understand the student populations you are serving in new ways. For example, you may find that socioeconomic status is a more important issue to be addressing. By looking at data in different ways, you gain a clearer understanding of the issues, and this can only help you in creating strategies that will help you address those specific issues.

The vision and data landscape phase is critical because it will inform what kinds of strategies and approaches you should invest the time in planning and implementing. Everybody's time, money, and other resources are precious. So, when you're thinking about what you're doing, not only should it be informed by your vision and what you are trying to accomplish, but it should be informed by what you know about the students that you are trying to impact. It should take into account your local context, institutional mission, and priorities. What a

neighboring institution, or one across the country, is doing may or may not be the strategy or intervention that is relevant for your student body, your faculty expertise, your institutional mission, your community partners, etc. Local context matters here.

While it is important to learn from others, it is just as important to uncover how what you learn is relevant to your students and their needs and is a match to your faculty expertise, interests, and passions. When I was at Fresno State, we had a focus on retention and the gaps in underrepresented student success. I was Dean of the College of Science and Mathematics at that time. We were looking across all of our STEM programs and the programs that other California State University institutions were putting in place, like summer boot camps where students start early and typically spend a month or more. Our students in the Central Valley of California needed their summers to work so they could afford tuition, rent, and books. So, while we thought a summer boot camp was a really good idea, we had to modify it to fit our local context by implementing something much shorter before the year started. We then spread out other aspects of the summer bridge experience into the academic year. We liked that idea, and we thought it would work, but we modified it to fit our situation, our context, our students, and our mission. Here is an example from the University of Wisconsin system: The Board of Regents passed a requirement that all of the universities would use a common cutoff score for the math placement test. We have 11 or so comprehensive universities, plus two-year colleges, and Milwaukee and Madison are the research universities. While this was a Board decision, an important part of implementation was that they allowed each campus to develop their own plan as to which type of course the students below the cutoff scores would be placed into. That gave our math department an opportunity to then respond in context by enhancing already developed co-requisite courses as well as developing a new quantitative reasoning pathway for non-STEM majors.

You have handouts on the tables from the publication where the model is described in more detail. These handouts can be used to determine where you might be in this model right now in your project and how well you are prepared to fully execute your plans. You can download the publication as a PDF or you can order it as a book by visiting the site at the Association of American Colleges and Universities:

<https://secure.aacu.org/imis/ItemDetail?iProductCode=PKALSTSS>. One of the tools in the book (and provided on your tables) is what we call a Readiness Survey. As you are reflecting on your project, you might look through there, and I'm hoping that it helps you think about how ready you are to enact the various stages of the River Model of Systemic Institutional Change. It was meant to prompt you to think about the various aspects of an institutional change strategy that are important for you to consider. Some of the items are things that people may not think readily about, so we hope that it helps you identify some new areas you need to explore.

I will close with the following thought: In all of this, leadership is critical. You are all here because you are leading; you are participating in various projects. There are people on campuses like provosts, deans, or department chairs who are what we might call positional leaders. They have a position, a title, that identifies them as a leader with specific responsibilities. Those individuals, I believe, have a responsibility as well as an opportunity to support and enable your work, so they should not stand by passively, but they should be engaged with you in your work. They are an important partner. Another kind of leader is people without a title like dean or chair, but who might be project managers, program directors, or members of the faculty or staff. These kinds of leaders might be referred to as informal leaders, who also have a responsibility and an opportunity to be involved in significant change efforts on campus. When these two kinds of leaders work together to achieve common goals, that is when campuses realize the most success. One way to think about how to bring different kinds of leaders together is through a model of shared leadership. Shared leadership involves engaging more people in leadership roles, interchangeable leader and follower roles, consideration of multiple perspectives, assignment of leadership not necessarily based on position or title, and collaboration and interaction across departments and units. For solving complex problems, this kind of model may help you take a new and perhaps more successful approach. It's

not one person, it's not even a small group, but it takes a village of people of all kinds and types in your institution working together to make a big difference.

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Exploring the AMTE Standards: Social Contexts of Mathematics Teaching and Learning and NCTM's Catalyzing Change in High School Mathematics

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Headlines from the news, June 2018:

“College Apologizes to Native American Brothers Detained After Joining Campus Tour”; “Toronto Principal Faces Resignation Calls After Making a List of Black Students”; and “After Melania Trump’s Jacket, People are Buying ‘I really do care’ T-shirts to Raise Money for Immigrant Charity”

Given that every other headline today wreaks of inequities that exist in society, it is more important than ever before that secondary mathematics teacher candidates are well prepared to ensure each and every student is cared for in a manner that will allow the student to reach his/her full potential. Caring in education has many meanings. In fact, Noddings (1995, p. 24) stated the following:

All teachers should be prepared to respond to the needs of students suffering from the death of friends, conflicts between groups of students, pressure to use drugs or engage in sex, and other troubles of today’s children. Too often schools rely on experts—“grief counselors” and the like—when what children really need is the continuing compassion and presence of adults who represent constancy and care in their lives. Artificially separating the emotional, academic, and moral care of children into tasks for specially designated experts contributes to fragmentation of life in schools.

Recognition that school is a place in which students are cared for and learn to care should be powerful in guiding policy.

Secada (2003) discussed a continuum of caring. On one end of the continuum, caring could be used to protect students’ emotional and psychological well-being. In this case, a teacher may seek to avoid all risk of adding further to children’s trauma. For example, a teacher may not push a student from a low socioeconomic status home to do challenging work. In the moment, the teacher may feel that she is shielding the student from additional stress; however, in the long run, the student will not have developed problem-solving skills or other skills that would benefit the student in and beyond the classroom. On the other end of the continuum, caring could be used to motivate proactive interventions, in which teachers push students to increase their knowledge in order to have a variety of options in life.

The video case of Amari Mitchell, a 16-year-old junior at Hoover High School, demonstrates the importance of a caring teacher (Dunigan, 2017). In the video, Amari, an African American student, describes an academic year in which he had one white mathematics teacher for half of the year and another white mathematics teacher for the second half of the year. He stated that the first teacher did not appear to care about him. He felt as if she did not seek to ensure that he was learning. He felt that the teacher ensured that the white students got what they needed, but she did not reach out to him. He said that his parents became his teachers, instead of his teacher. He stated that some teachers don’t care about certain students. They care about students that look like them. He felt that he was solely responsible for his learning. During the second half of the year, he had a different white teacher in the class who pushed him to get help from her and to work hard himself. He talked about how

this teacher reached out to his mother to ensure that he was doing his work. He stated that this teacher was not going to allow him to fail and that the only reason he would fail was if he allowed himself to fail. Amari helped us to see that teachers' actions as well as their inactions send students micromessages that either encourage them and move them forward or make them feel less than and discouraged.

Furthermore, Amari made it clear that some students face inequities in school due to their race/ethnicity. Amari's depiction of what happened to him is in alignment with the following quote:

There is a long-standing, thoroughly documented, and seemingly intractable problem in mathematics education: inequity. Children of certain racial, ethnic, language, gender, ability, and socioeconomic backgrounds experience mathematics education in school differently, and many are disaffected by their mathematics education experience. (Aguirre et al., 2017, p. 125)

As mathematics teacher educators, we must ensure that secondary mathematics teacher candidates are able to not only understand and address the issues mentioned in the preceding quote, but that they must also be able to address and understand their beliefs about and the needs of lesbian, gay, bisexual, transgender, queer or questioning (LGBTQ) students, and address the needs of students who identify as being in the intersection of multiple groups.

In addition, teacher candidates must understand that "educational equity means that every student has access to the educational resources and rigor they need at the right moment in their education across race, gender, ethnicity, language, disability, sexual orientation, family background and/or family income" (The Aspen Education & Society Program and the Council of Chief State School Officers, 2017, p. 3). Teacher candidates also need to understand that bidirectional relationships between schools and families support equity—that is, equity should be extended from a unidirectional exchange as primarily benefitting the growth of students and student groups that have historically been denied equal access, opportunity, and outcomes in mathematics to a reciprocal approach (Civil, 2007). Culturally sustaining pedagogy (CSP) is a means through which teacher candidates can create an equitable classroom environment (Paris, 2016). Below are characteristics of CSP:

- CSP describes teaching and learning that seeks to perpetuate and foster linguistic, literate, and cultural pluralism as part of the democratic project of schooling and as a needed response to demographic and social change.
- CSP takes dynamic cultural and linguistic dexterity as a necessary good, and sees the outcome of learning as additive, rather than subtractive, as remaining whole rather than framed as broken, as critically enriching strengths rather than replacing deficits.
- CSP builds on decades of crucial asset-based pedagogical research that has countered pervasive deficit approaches, working against the backdrop of beliefs in White superiority and the systemic racism they engender, to prove that practices and ways of being as students and communities of color are legitimate and should be included meaningfully in classroom learning. (Paris, 2016, p. 6)

Another aspect of caring for students is to provide them with information about possible career paths and the road maps for attaining the different professions. Teachers need to especially share information about science, technology, engineering, and mathematics (STEM) careers. People from underrepresented groups have made some progress in STEM but remain underrepresented in STEM as a whole and are particularly underrepresented in some STEM fields, notably engineering, mathematics, computer science, and some of the physical sciences (Committee on Equal Opportunities in Science and Engineering 2015–2016 Biennial Report to Congress, Executive Summary, p. i).

There are two national documents that can be used to help develop the sociopolitical awareness and agency of secondary mathematics teacher candidates: the Association of Mathematics Teacher Educators (2017)

Standards for Preparing Teachers of Mathematics and *Catalyzing Change in High School Mathematics* (National Council of Teachers of Mathematics [NCTM], 2018). In this session, both documents were discussed with regards to their emphasis on the sociopolitical context of mathematics teaching and learning and how each can be used in preparing secondary mathematics teacher candidates.

Standards for Preparing Teachers of Mathematics (SPTM)

The SPTM is a set of comprehensive standards describing a national vision for the initial preparation of all teachers, pre-K–12 who teach mathematics. These standards are aspirational, rather than describing minimum levels of competency needed by beginning teachers. Their purpose is to guide the improvement of teacher preparation programs, inform policies and practices, and promote national dialogue and action (AMTE, 2017). The structure of the SPTM document is listed as follows:

- Ch. 1: Assumptions and Overview
- Ch. 2: Candidate Knowledge, Skills, and Dispositions
- Ch. 3: Program Characteristics to Develop Candidate Knowledge, Skills, and Dispositions
- Ch. 4-7: Grade-Band Elaborations (Early Childhood, Upper Elementary, Middle Level, and High School)
- Ch. 8: Assessing Mathematics Teacher Preparation
- Ch. 9: Enacting Effective Preparation of Teachers of Mathematics

Assumption #1 of the SPTM specifically focuses on equity in mathematics education:

Ensuring the success of each and every learner requires a deep, integrated focus on equity in every program that prepares teachers of mathematics. (AMTE, 2017, p. 1)

Within the text related to the assumption the authors make it clear that equity must be both addressed in its own right and embedded within every standard. They further assert that every standard must be built on the premise that it applies to each and every student, recognizing that equity requires acknowledging the particular context, needs, and capabilities of each and every learner rather than providing identical opportunities to students (AMTE, 2017, p. 1). Standard C.2 provides an example of how equity is a strand in every standard (see Figure 1).

Standard C.2. Pedagogical Knowledge and Practices for Teaching Mathematics

Well-prepared beginning teachers of mathematics have foundations of pedagogical knowledge, effective and equitable mathematics teaching practices, and positive and productive dispositions toward teaching mathematics to support students' sensemaking, understanding, and reasoning.

- C.2.1. Promote Equitable Teaching
- C.2.2. Plan for Effective Instruction
- C.2.3. Implement Effective Instruction
- C.2.4. Analyze Teaching Practice
- C.2.5. Enhance Teaching Through Collaboration with Colleagues, Families, and Community Members

Figure 1. Standard C.2 from the AMTE (2017) Standards (p. 126).

Standard C.4 is the standard that specifically addresses mathematics education in its sociopolitical context (see Figure 2).

Standard C.4. Social Contexts of Mathematics Teaching and Learning

Well-prepared beginning teachers of mathematics realize that the social, historical, and institutional contexts of mathematics affect teaching and learning and know about and are committed to their critical roles as advocates for each and every student.

Indicators include

C.4.1. Provide Access and Advancement

C.4.2. Cultivate Positive Mathematical Identities

C.4.3. Draw on Students' Mathematical Strengths

C.4.4. Understand Power and Privilege in the History of Mathematics Education

C.4.5. Enact Ethical Practice for Advocacy

Figure 2. Standard C.4 from the AMTE (2017) Standards (p. 129).

Chapter 7 is the Grade-Band Elaboration chapter for Grades 9–12. Within this chapter are vignettes and other resources that may be used by mathematics teacher educators to help teacher candidates to understand and develop competencies related to the standards. For example, Figure 3 contains an indicator for Standard C.4, an accompanying vignette from Chapter 7, and some discussion questions related to the vignette.

C.4.2. Cultivate Positive Mathematical Identities

Well-prepared beginning teachers of mathematics recognize that their roles are to cultivate positive mathematical identities with their students.

Hs.4. Cultivating Positive Mathematical Identities in Each and Every Student

Well-prepared beginning teachers of mathematics at the high school level draw on students' strengths to cultivate positive mathematical identities. [Elaboration of [C.4.2](#) and [C. 4.3](#)]

Vignette 7.3. Mathematical Identity

I am Michael Davis, an African American junior in a geometry class. I am motivated to do well in this class because I want to go to college, and if I make good grades, I might get a scholarship. I actually like this class because I am given opportunities to solve problems in groups with my peers. I like the discussions that we have, especially debates when we do not agree on a solution. I like activities that allow me to discover important connections between different topics of mathematics, between my life and mathematics, and between mathematics and what is going on in social media and the world. I also like making conjectures and testing them to find out if they are true. (SPTM, 2017, p. 130)

Possible Discussion Questions Related to the Vignette

- Why might Michael feel the way he does about mathematics class?
- Given that Michael is a Black male, what might be noteworthy about his experience?
- Why might he enjoy working in a group? What does it take to develop meaningful *group-worthy* problems for students to solve?
- What would support the development of a classroom culture in which group work is valued? What are the differences between problems and exercises?
- Why might Michael care about relating mathematics to other topics, his life, social media, and the world? Should these connections be made between things with which he is already familiar, or can they also expand this knowledge? How does a teacher orchestrate this discussion well? (SPTM, 2017, p. 130)

Figure 3. Vignette 7.3 from the AMTE (2017) Standards (p. 130).

In addition to the information in Chapter 7 of the SPTM, mathematics teacher educators may discuss identity and agency in more detail as a supplement to the discussion about the vignette. The following sources are helpful for the discussion: Aguirre, Mayfield-Ingram, and Martin (2013); NCTM (2018); and Solomon (2009). Figure 3 provides one example of how rich discussion can be built around the SPTM and the elaboration chapter.

Catalyzing Change in High School Mathematics

The purpose of *Catalyzing Change in High School Mathematics* (NCTM, 2018) is to open serious discussions among the key stakeholders in high school mathematics education to engage in resolving the barriers that have long impeded meaningful and necessary change in high school mathematics education. The document contains four key recommendations:

- Each and every student should learn the Essential Concepts in order to expand professional opportunities, understand and critique the world, and experience the joy, wonder, and beauty of mathematics.
- High school mathematics should discontinue the practice of tracking teachers as well as the practice of tracking students into qualitatively different or dead-end course pathways.
- Classroom instruction should be consistent with research-informed and equitable teaching practices.
- High schools should offer continuous four-year mathematics pathways with all students studying mathematics each year, including two to three years of mathematics in a common shared pathway focusing on the Essential Concepts, to ensure the highest-quality mathematics education for all students.

NCTM (2018) is a must read for secondary mathematics preservice teachers and can serve as a companion to the SPTM Grades 9–12 elaborations chapter. It is important for teacher candidates to be cognizant of the different purposes of mathematics so that they are able to provide their students with the opportunity to learn meaningful mathematics that will give them tools and open doors to a variety of career options. It is important for teacher candidates to discuss the perils of tracking and other inequitable school structures so that they will develop a sense of agency that drives them to advocate for each and every student’s right to a mathematics education that will allow them to be career- and workforce-ready. Moreover, NCTM provides action steps that teachers and others can take to ensure that students receive an equitable mathematics education.

Challenge for the MTE-Partnership

It is imperative that the MTE-Partnership examine SPTM (AMTE, 2017), NCTM (2018), and other resources that will enable the Partnership to develop an equity lens to oversee the work that we are doing to tackle the “wicked” problem of the downward cycle in mathematics education described by Suzanne Wilson and adapted to the MTE-Partnership research action clusters (RACs) by W. Gary Martin (Martin & Strutchens, 2018). See Figure 4.

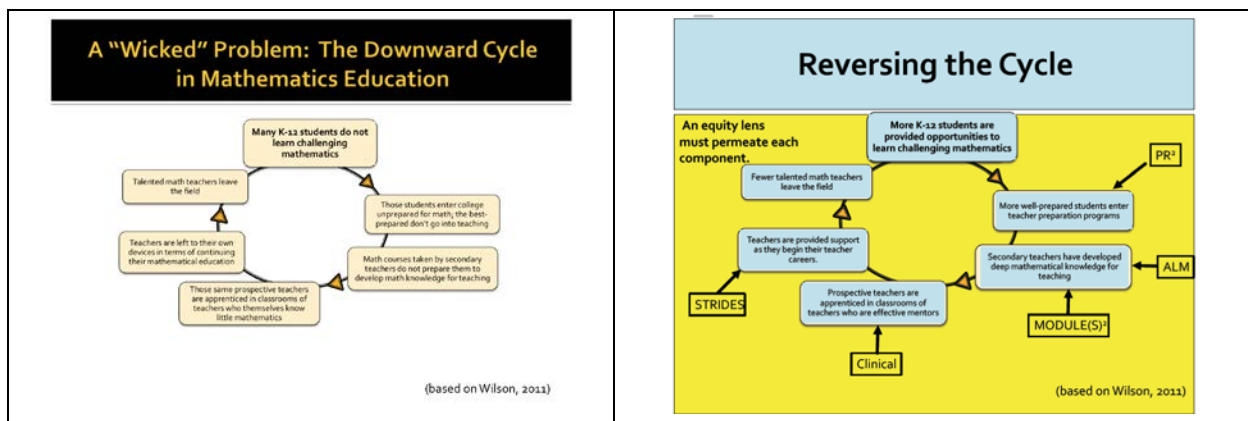


Figure 4. The “wicked” problem in mathematics education and reversing the cycle.

Through an equity lens, the Program Recruitment and Retention RAC can develop modules and other resources that will help colleges to recruit and retain more well-prepared students from a variety of backgrounds including racial, socioeconomic, linguistics, and others into teacher preparation programs. Through an equity lens the Actively Learning Mathematics RAC will develop courses and other resources that will enable mathematics professors to provide teacher candidates and other mathematics majors with the opportunity to learn mathematics in a manner that helps them to understand the mathematics and apply it their lives daily. Moreover, the MODULE(S)² RAC will develop resources to help secondary mathematics education programs to provide courses in which the teacher candidate develop mathematical knowledge for teaching. Through an equity lens the Clinical Experience RAC will develop resources that will provide professional learning for the mentor teachers who host teacher candidates in their classrooms to ensure that the teacher candidates are being apprenticed by mentor teachers who care deeply about the well-being and mathematical success of each of their students. Through an equity lens the STRIDES RAC will develop resources that will help secondary mathematics teacher education programs to follow up with their program completers and build partnerships with schools in order to support and retain well-prepared beginning teachers. And if the equity lens is used well throughout each of the MTE-Partnership RACs and partnership teams (mathematicians, mathematics teacher educators, mentor teachers, school administrators, and teacher candidates) work together, more K–12 students will be provided opportunities to learn challenging mathematics.

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Joint Q&A: Equity in Program Transformation, Susan Elrod and Marilyn Strutchens

This question-and-answer session was transcribed by the Bureau of Sociological Research at the University of Nebraska-Lincoln and edited for formatting. Audience questions were facilitated by W. Gary Martin.

Marilyn Strutchens: One of the things Susan mentioned during her talk was the Pell-eligible underrepresented groups not graduating at the same rates as others, and so I asked her, “What are things that they are doing to find out what’s happening with these students? Is it a systematic thing? Is it across the teachers that they’re encountering or is it something that they believe about themselves? What factors are causing the Pell-eligible students not to graduate?”

Susan Elrod: And I said, “Marilyn, that’s a great question; we don’t quite know yet.” We are just coming to grips with the data, and I was just explaining that when we look over time, rates for these students, underrepresented minority or not, have been flat. There has been no change up or down for over 10 years. So, this is a persistent problem, and what we don’t know is why these students may be dropping out more often than others. Now we have to go back into the data, there are first-generation students in there, there are underrepresented students, there are majority students; we need to look deeper. Consequently, at the same time, the institution has established an emergency fund to help students with short-term financial issues. They’re starting up like wildfire across the country. And, we now have a food pantry on campus. We are also starting a program for children who come through the foster system. It turns out this may be an invisible population of students on your campus. There’s no real way to identify them, but what do children who come through foster youth not have? The kind of support that comes from a family. When they age out of the system, they may become homeless at times, like over the winter break. So now we have a fund that our alumni and others can donate to, to pay for the housing of students over winter break. These are just some of the issues that we’re starting to address and will be addressing more because of our interrogation of the data. Now that we are aware of it, we cannot *not* address the issue.

Strutchens: At the end you talked about shared leadership. How do you see that relating to the networked improvement communities?

Elrod: That’s a great question. I would ask, “Who is involved in the RACs?” What kinds of people—are there deans, are there department chairs, is there a provost somehow involved? I know it’s hard sometimes to get your provost to get involved because they have so many commitments. Whoever is in the RAC is great, but you might think about how to expand in different ways and to engage a variety of others. Another group that I think is important to think about are the people in your Student Affairs division. They are doing things that impact your students that you may not be aware of, and they may be doing something that overlaps or is working at odds with what you are trying to accomplish. More than likely, they could be your new best friend and collaborator. If you looked at the histories of how university budgets have changed over time, one of the biggest growth areas is the Student Affairs operation; it has grown in terms of resources invested to address the issues that we know we face with students. So, there are resources there to consider! But, I would say to think broadly about whom you are engaging; maybe the RAC has a particular group of people involved. Think about peripheral engagements with others or who you can tell about your project so that they might get engaged in it or connect you to someone else who might. You might be surprised at how many people might be interested in what you’re trying to do. Even though your work is

about math teacher preparation, there could be all kinds of common bonds and synergies that you might discover by reaching out beyond your typical circle of people.

I wanted to go to Marilyn's last slide that showed all kinds of systemic change projects. How might you think about that work in the context of the River Model; is there anything in there that you could connect back into the model? For example, one question I had was, "What might be a vision?" I mean I actually see several visions all around that slide, such as more well-prepared students entering teacher preparation programs, so we'd have more well-prepared teachers. That one stuck out to me. There is a PR² abbreviated intervention listed there too. What is that intervention and what is the data connected to it; how are you going to know it will work?

Strutchens: I think looking at our cycle, we all began with the MTE-Partnership Guiding Principles and that kind of helped us all to have a vision about what we wanted the goals in our secondary mathematics teachers to be and so when we created our RACs, we made it into that vision. PR² used to be the MATH RAC. It's now Program Recruitment and Retention. A part of PR² can relate to some of the work that you just talked about in terms of, "What are some reasons why students are falling out of programs; how can we change programs so that they meet the needs of more students so that more students stay in? The Actively Learning Mathematics RAC focuses on the first two years of college in terms of changing the way that college mathematics is taught so that more students can make sense of it and really engage in it and be able to apply it to their situation. It's not only helping secondary math teachers but also teaches students in other fields. We have this vision about what we want our standard of secondary mathematics teachers to look like and so within our RACs we're working toward that vision.

Elrod: What kind of data are you looking at? How are the RACs going to know they're successful at it and making sure this is happening?

Strutchens: We have two working groups that are forming into RACs. They're going to help pull all of this together. Right now, I think all of us have our individual RACs, and we have our driver diagrams and our goals of what we're trying to reach individually as RACs, and our vision of our goal is standard as a network recruitment community. But the working groups like the Transformations Working Group comes together to help people to think about how involvement in multiple RACs can really transform the programs so that we could reach the gold standard that we use.

A question from the crowd: "I wonder if we do enough to consider how we bring districts that represent radically different equity profiles in dialogue with each other through partnerships so it can work across the school districts."

Strutchens: Often within our professional development with teachers, we work across districts because we work in an area where there are a lot of small districts. Bringing teachers together from different districts and having these kinds of conversations using catalyzing change is a way of getting teachers to think about those issues (and also administrators). Using different vignettes to talk about students' experiences can really help teachers to think about these issues at a different level, such as showing them the video of Mauri, showing them a video of other students who talk about their experiences in schools, showing them the voices of students who have gone through school systems and why things must change.

Robert Berry has some case studies of African American boys, Katherine Chval has different case studies of gifted students, we can find a lot of different case studies that we can use with teachers to help them really think about students and their experiences. The National Council of Supervisors in Mathematics also brings together people from a lot of different districts at their meeting and uses them. People express themselves by getting upset about

or in disdain about things that are happening in their districts and the need to change policies because often it is the policies that are really holding students and teachers back. So, how do you change the policies, how do we talk to administrators, how do you talk to not just district leaders but also state departments?

Audience question: “How do you handle the positional leader who doesn’t engage in the work?”

Elrod: Unfortunately, that is an all too common scenario. As I mentioned before, I think a more shared leadership model is much more effective. When I think about a shared leadership model, I realize that it requires everybody to be on board with that model, including the administrators. I would say to the faculty in the room who are working diligently and can’t get the attention or engagement of positional leaders, the best way to work around that reality is to form alliances and to build up a critical mass of faculty leaders. It’s much more difficult, it takes longer, and it is harder because you may not have access to the resources you need, so it is not optimal. Think about your sphere of influence or beyond, talk about what you are doing with others, and you might be able to find an ally in an unexpected place like in Student Affairs. If you can’t get the dean on board, maybe you can get the Vice President for Student Affairs on board or think about a chair of another department who might have similar concerns or goals. Think about the alliances that you can create in your sphere of influence and find the people who are with you and then go from there; again, it’s harder, it takes longer, and you may not get what you need to get done as quickly. You may also have change course to accommodate the environment, which is not something that we’re often willing to do, but it is something you may have to think about doing. So, be patient and flexible. Hopefully, that’s helpful.

Audience question: “How do we create a system that does not just give someone bread crumbs but emancipates people from colonialism?”

Strutchens: I think it takes more than a few people talking about equity issues in order to change systems. I was involved in a strategic planning committee for the state department in Alabama and the major people who were talking about equity issues were African Americans and then Basil was on the strategic committee (and he’s one of our students so definitely he was talking about equity issues) because he cares, and so it takes more than people of African American decent fighting battles for African American students. It takes more than just women fighting for gender issues in order to make things change; it takes all of us fighting for these issues for change together. Gary wanted me to put up a slide about my acronym for WOKE and it’s: W for wondering when things are going to change so that we can really see a difference, O for it’s an ongoing mission of mine to change things, K for keeping fighting no matter what situation I’m in, and then E for equity because it is always on my mind.

So, stay WOKE, because people throw that word around. But what does that mean, “Are you woke?” We were talking about in our Clinical Experiences RAC that we can’t just talk about the issues that are close to our hearts, we have to think about the issues that are facing each and every student in our classroom. In order for things to change, in order for us to emancipate people, we have to come together, we have to be voices. We can’t expect just the people who do research on equity to change things; it has to be all of us working together to change things. When we look at the data from the first discussions about “broadening participation,” we’ve been talking about these numbers for years, there were a lot of gaps in terms of student achievement and it’s not just based on students’ abilities, it’s based on what they have the opportunity to learn. So, how do we as a people, how do we as Americans, how do we change what’s happening to our students on a day-to-day basis and just be people who study equity issues who help make the changes happen. It has to be people who care in general about education.

Audience question: Someone asked about persistence, the importance of persistence and in trying to keep the vision alive.

Elrod: Right. Staying WOKE. I think to me it goes back to the “it takes a village” concept. I see too often a single passionate champion who just burns out because they are the only one. How many of you in this room, don’t raise your hands ... I think in order to keep the momentum going, to stay persistent even in the ways that Marilyn was talking about, you have to enlist other colleagues and get people working with you. I think that’s especially important because somebody may move on to be department chair, somebody may go on sabbatical, somebody may take a leave of absence, or take another job; there’s always change and so the way you can buffer yourselves against change is to make sure you have enough of an army of people with you. One of the challenges I think we all face is: How do we build the army? How do we convince others of our passion? I think it’s important for everyone to get outside of yourselves just a little bit and try to learn about what others care about or are interested in and then connect your passion to that. Find common ground to enlist others and then you will hold each other up and form a larger community of people who can really keep the momentum going and, hopefully, for the long run.

PANEL TALKS AND WORKING GROUPS

Transformations Panel

Panelist Alyson E. Lischka

The Middle Tennessee MTE-Partnership: Growth and Opportunities

The Middle Tennessee Mathematics Teacher Education Partnership, a founding partnership in the MTE-Partnership, continues to grow in both its use of and contributions to the research base developing through the MTE-Partnership. Anchored at Middle Tennessee State University (MTSU) and supported by the Tennessee STEM Education Center and Rutherford County Schools, the Middle Tennessee Partnership members provide leadership in the MODULE(S²) Research Action Cluster (RAC) and actively participate in the MATH/Program Recruitment and Retention (PR²) RAC.

Following several leadership changes in the early stages, the Middle Tennessee Partnership has more recently evolved into a clear mechanism for program improvement at MTSU. A direct result of the local partnership has been increased communication across departments and colleges involved in the preparation of secondary mathematics teachers at MTSU. By inviting faculty from a variety of departments and colleges to participate in the work of the MTE-Partnership, our local partnership has grown in strength and begun to implement the tenets of a Networked Improvement Community (NIC; Bryk, Gomez, & Grunow, 2010).

With a focus on data related to recruitment and retention, we have developed a database of every student enrolled in a course in our program, which allows us to follow those students through the program. We use this tool to identify points at which students choose to leave the program, pinpointing areas for improvement in our courses. In addition, the database provides data that increases our understanding of the demographics of our students, which enables us to make informed discussions about equity and social justice initiatives.

To address the recruitment of students into our program, the partnership team has utilized *The Secondary Mathematics Teacher Recruitment Campaign Implementation Guide* (Ranta & Dickey, 2015) generated by the MATH RAC to develop more effective recruiting tools. Our recruitment initiatives now include extensive social media campaigns, a variety of campus events, and a recruitment video. The video, a direct result of the MTE-Partnership connection, is utilized at each MTSU new student orientation held throughout the summer as part of the dean's welcome. As a result of these increased recruitment efforts, we are experiencing a rise in the number of students taking introductory courses in our program.

In addition to recruitment efforts, materials produced by the MODULE(S²) RAC are being implemented in our content courses for middle grades and secondary teachers. Analysis of Praxis data and the concern that prospective teachers are struggling to connect their content learning with teaching spurred faculty to incorporate the materials into courses. The College Geometry instructor uses MODULE(S²) materials exclusively and other course instructors implement materials from the Algebra, Statistics and Probability, and Modeling materials. Across all of the courses, the implementation of these materials has provided a vehicle for rich mathematical discussions that challenge our prospective teachers to consider their learning in connection to the mathematics they will teach. In addition, the materials require prospective teachers to consider how K–12 learners might engage with particular topics and thus challenge the prospective teachers to develop the mathematical knowledge needed for teaching. We have anecdotally observed evidence of these ideas carrying over into methods courses and student teaching and are beginning to gather data that will further demonstrate the effectiveness of this program transformation. A positive indication of the impact of these changes is shown in the fact that all of our graduates for the 2017–2018 academic year graduated with a passing score on Praxis.

Other program improvements generated from participation in the MTE-Partnership and the resulting increased program communication involve diversity initiatives and changes in our student teaching placement model, gleaned from the Equity and Social Justice Working Group and Clinical Experiences presentations, respectively. Our program, in collaboration with the MTSU Intercultural and Diversity Affairs office, instituted a diversity panel discussion in which minority teachers from our area shared their experiences with future teachers, encouraging minority students to enter the teaching profession. The event was well-attended, and we hope to make this an annual event on our campus. Another result of increased communication for our program has resulted in new placement practices for our student teaching placements. Our mathematics education faculty now collaborate with College of Education faculty in placing our students in pairs in schools and assigning one supervisor to work with both intern-mentor pairs in each school.

Learning from the MTE-Partnership has propelled progress in our local partnership in many ways and, at the same time, demonstrated areas for further growth. As our local partnership continues to seek improvement, we have several challenges ahead. First, the increased interest generated through our recruitment efforts does not always draw students with strong academic records. We are continuing to seek ways to support students who show great potential as mathematics teachers but have weaknesses in their mathematical histories. These conversations require not only collaboration with education and mathematics education faculty but also the mathematicians who will need to support their mathematical development. Second, as we attract more students who are English-language learners, learning how to support them through successful completion of Praxis requirements becomes another challenge. Third, although our communication concerning student teaching placements has improved, we are still lacking skilled mentor teachers to work within schools. As more of our graduates become eligible to serve in this role, we hope to develop a larger cohort of mentor teachers with whom we can place our student teachers. This also points to the need for a deeper collaboration between our university and school partners.

As we look forward to next steps for our Middle Tennessee MTE-Partnership, we are excited to begin talks with Tennessee Technological University as they consider becoming a member of our partnership. We look to other multi-institution collaborations in the MTE-Partnership to guide us as we move forward in these talks and consider how the collaboration can benefit both institutions and the greater Middle Tennessee area.

Panelist Jeremy Zelkowski

Transforming the University of Alabama's Secondary Mathematics Teacher Preparation Program

Since the start of the 2010–2011 academic year, prior to the onset of the Mathematics Teacher Education Partnership (MTE-Partnership), our program at The University of Alabama (UA) has received extensive revisions in collaboration between the faculty from both the mathematics, and curriculum and instruction departments. The strength behind our transformation is the 10-year partnership (to-date) between our faculty of these two departments. We also began an outlay of setting the program up for the National Council of Teachers of Mathematics (NCTM) Specialized Professional Association (SPA) accreditation process with data collection that began in the 2011–2012 academic year. While many changes have occurred that have been positive which we report on, additional changes continue that require administrative support and external funding support. We present an overview of this transformational work, as well as our struggles in moving forward.

Starting the Transformation

When the Conference Board of the Mathematics Sciences (CBMS) published *The Mathematics Education of Teachers II* (MET II) in 2012, our program had already been working at making small modifications based on the MET I from 2001 using existing structures (CBMS, 2001, 2012). Drs. Jim Gleason and Jeremy Zelkowski began their

collaboration a few years earlier. The first programmatic changes included revising the mathematics education math major track of courses to align more closely to the MET I, as well as sequencing mathematics methods courses with a developmental trajectory in place. We also focused heavily on changing prerequisites to courses. That is, we added specific mathematics course prerequisites that are required before students can begin their final two years in the program. We noticed many students taking courses sporadically. At the start of the third year (upper division), many students entered their first methods courses yet to complete basic Statistics, the Calculus sequence, and/or the intro to proofs / Discrete Mathematics course. At the time, the program had only a single content course specifically designed and required for secondary mathematics teachers, a Geometry course. The remaining courses in the math major were math major courses.

Establishing the UA West Alabama Partnership Goals

At the onset of the MTE-Partnership, we worked to have our deans, provost, local in-service center, and two school-system partners comprise our partnership team. Our new focus would be addressing the MET II and the MTE-Partnership Guiding Principles while paying particular attention to the NCTM SPA requirements. In our partnership goals, we targeted four major areas for improvement. First, we set to develop of a sequence of capstone *advanced perspective* mathematics courses our third-year candidates would complete. Second, during the same academic year, we sequenced two math methods courses—both with introductory clinical field placements—alongside general secondary education program requirements. Third, we sought external funding to begin working with a team of local partnership math teachers in a Professional Learning Group (PLG) focused on the implementation of the mathematical practice standards of the common core in their teaching. This group would become the preferred teachers to place teacher candidates within the field. In addition, the PLGs participated in a broader project that developed the Mathematics Classroom Observation Protocol for Practices (MCOP²; Gleason, Livers, & Zelkowski, 2017). Last, we sought to improve the structural components of how the final two years of the program would be offered (as a cohort) with benchmarks that teacher candidates were required to meet at the end of each semester in order to move forward.

Enacting the Goals to Transform the Program

Our first goal of developing and offering a sequenced set of capstone content courses began with piloting and integrating changes in the existing History of Mathematics course with the content areas of function, number systems, rings, and integral domains. The course served as the prerequisite to the Geometry course focused on transformations (see Zelkowski, Campbell, & Gleason, 2018). By the start of the 2014–2015 academic year, we changed the program’s mathematics major by inserting the new capstone course in place of the History of Mathematics course. The historical aspects of the NCTM SPA standards are still included across both courses, as adding a course was not possible and replacing a course was our only option.

The second goal focused on the sequencing of math methods courses with the intent of taking teacher candidates from novice lesson planners to well-prepared, proficient unit planners and implementers of high-quality mathematics lessons. We sequenced three methods courses prior to student teaching internships with a major individual SPA assessment at the conclusion of each semester. The first methods course focused on lesson planning with technology where appropriate technology use is the focus. The second course focused on the content of lesson questioning and tasks. The third included a five- to 10-day unit of instruction focused on making connections and sequencing content while considering the use of technology, questioning, and tasks. Teacher candidates must successfully score well on three live observations of enacted lessons to qualify for the student teaching internship (Zelkowski & Gleason, 2016).

The third program transformation goal included building a high-capacity network of teachers who would supervise teacher candidates during clinical field placements. We secured five years of funding with two grants to

work with about 26 teachers. In working with our two local school systems, we spent the better part of five to seven days each summer and four to five PLG days during the school year, working with these teachers. To date, half of these teachers remain locally, with an additional few other teachers lacking the state required credentials to host student teaching interns. At the onset of starting the PLG, the development of the MCOP² allowed for a shared vision of how teacher candidates would be assessed by both program faculty and supervising mentor teachers. The MCOP² work was the highlight of this goal. While this goal has been partially met, when we have a large group of interns, the network is not large enough to provide the highest-quality experiences for interns and earlier clinical students.

The last goal was putting the structure of the program together so that courses were well-sequenced with a programmatic design for a two-year set of preparation courses for undergraduate and alternative-masters certification seekers. In either pathway, we have eliminated the idea or option of a 12- to 16-month pathway. We only offer a four-semester, two-year sequenced pathway of mathematics and methods courses to gain an initial teaching credential. The common courses in each semester for all teacher candidates helps build continuity, community, and professional relationships that well-prepared beginning teachers need. Teacher candidates in each cohort are enrolled in 12, 10, and 9 hours together specifically in each semester prior to the internship. These 31 hours are specific to mathematics education students only (bachelor and post-baccalaureate). In some instances, general secondary education coursework and other mathematics courses may result in teacher candidates enrolled in as many as 46 hours over these three semesters.

Meeting the Goals and Areas of Improvement

While we felt strongly about the ability to transform the programmatic coursework and other related components, changes in administration since the UA partnership was established and traditional views of secondary education have made it difficult for a full transformation to be made. With regard to the four MTE-Partnership Guiding Principles, we feel our team has helped fuel principle #1 at the national level. We have partially met principles #2 and #3, as some data has not been provided at the college level to accurately assess programmatic effectiveness to the greatest extent possible. At times, we have received some administrative resistance to making programmatic changes that differ significantly from other secondary education disciplines. This has hampered our efforts to serve as a national framework for programmatic design with changes that meet the stated goals. Our partnership, we believe, has been active with respect to principle #4 by disseminating the results of our investigation of programmatic design and its impact on teacher candidates' knowledge and abilities entering the profession.

Summary

Many aspects of UA's secondary mathematics teacher preparation program have been transformed to align with the MET II, NCTM SPA, MTE-Partnership Guiding Principles, and the Association of Mathematics Teacher Educators' Standards for Preparing Teachers of Mathematics (2017). We have produced strong evidence of programmatic impact on the Praxis II math exam and edTPA assessment, while lacking some additional measures that may shed more light on identifying which changes produced which effects. Interns' long-term teaching practices are influenced by the extent to which cooperating teachers embrace and demonstrate a commitment to the NCTM eight teaching practices when interns are placed full-time in their classrooms. The MCOP² development has provided other MTE-Partnership teams a low-to-no-cost, well-validated, observational protocol to assess teacher candidate progress during preparation. While we acknowledge our successes with adding contributions to the MTE-Partnership, internally we also acknowledge the struggles to transform the program to the level of the MTE-Partnership gold-standard.

Panelist: Ruthmae Sears

University of South Florida MTE-Partnership Team Summary

The University of South Florida MTE-Partnership Team has undertaken initiatives to address the MTE-Partnership Guiding Principles. These efforts and their outcomes are summarized below by the various principles. Additionally, areas that hold promise, as well as challenges that USF mathematics education program are currently facing are identified.

Partnerships as the Foundation

As our team engages in partnerships across the university, we have been faced with institutional challenges. Particularly, we were impacted based on the reduction of mathematics education faculty, who left the university and their position was never replaced.

Nevertheless, we are committed to our collaborative ventures with the mathematics department and the College of Arts and Sciences. The pedagogy (mathematics education) and content (mathematics) faculty frequently engage in dialogue about means to develop our pre-service teachers' content knowledge and ensure that our pre-service teachers are able to pass their state certification examination. These interdisciplinary conversations have resulted in collaboration on posters and papers.

Commitments by Institutions of Higher Learning

The university's commitment to pursue a STEM focus resulted in faculty and students attending STEM training and serving on STEM curriculum enhancement initiatives. Additionally, USF's NSF sponsored STEER grant sought to promote evidence-based teaching that is student-focused. STEER offers support, recognition, and opportunities for faculty interested in adopting evidence-based teaching. This initiative has resulted in Teaching Assistants (TAs) training for STEM labs that emphasized student learning rather than solely covering the course curriculum. This grant further supported an institutional investment in developing effective teachers who exhibit effective instructional practices.

Commitments by School Districts and Schools

The faculty partnered with the local school district and Title 1 schools to provide pre-service teachers increased exposure to the challenges and complexities of teaching mathematics in a middle and high school environment. Additionally, teachers and administrators at local schools are encouraged to provide feedback on content that needs to be addressed in the middle and high school methods classes. As a result of their insights, greater attention was placed on developing pre-service teachers' content knowledge, ability to attend to equity within the classroom setting, and being culturally responsive. The focus on developing content knowledge aligns with the collaborative efforts between the mathematics education and mathematics faculty. Moreover, our partnering school district (Hillsborough County) identifies mentor teachers based on performance evaluations. This results in high-performing teachers with proven records of success working with our pre-service teachers.

Candidates' Knowledge and Use of Mathematics

Concerted efforts to attend to Common Core State Standards for Mathematics content standards and Standards for Mathematical Practice, in content and pedagogy courses developed pre-service teachers' mathematical knowledge and ability to apply mathematics in multiple settings.

Additionally, the faculty have sought to embed the use of technological tools more readily into the Methods courses, thus fostering the development of technological pedagogical content knowledge. For example, pre-service teachers are exposed to various technological tools, such as TI-Nspire, Vex Robotics, and Desmos. The use of technological tools increased the likelihood that pre-service teachers were willing to engage with higher-level cognitively demanding mathematical tasks.

Professionalism, Advocacy, and Leadership

Discussions in Methods classes raised awareness of the need to reflect on mathematical identities. Additionally, pre-service teachers are also encouraged to demonstrate personal integrity, and be mindful of how implicit bias can affect learning experiences. They were also encouraged to take leadership roles and reflect on their agency within the academic environment.

Clinical Experiences

Pre-service teachers are afforded an opportunity to engage with middle and secondary school environments in their methods courses, practicum, and final field experiences. As a result of a recent NSF funded grant (Collaborative Research: Attaining Excellence in Secondary Mathematics Clinical Experiences with a Lens on Equity) our faculty became aware of the need to increase the amount of time allocated for clinical experiences earlier in the secondary (Grades 6–12) mathematics education program.

Student Recruitment, Selection, and Support

Recruitment is primarily done by the advisement office. Nevertheless, due to enrollment concerns, faculty are encouraged to participate in recruitment efforts and reflect on the selectivity criteria, while maintaining the standards of the discipline.

Beginning and In-service Teacher Support

We currently do not provide continued support for beginning and in-service teachers without grant funding. We have a Robert Noyce Fellowship that funds Teacher Fellows.

Tracking Success

The state of Florida rates teacher education programs based on their graduates after five years upon completion. USF was ranked No. 1, due to the success of their graduates who worked in the state of Florida.

Promising Areas of Future Action

Collaborating with the College of Arts and Sciences faculty and infusing technology into mathematics education is quite promising. Hence, grants can be sought to further support these ventures.

Challenges

Admittedly, due to limited faculty on staff, the extent to which transformative ideas could be implemented is impacted. Thus, the mathematics education program could benefit from hiring new mathematics teacher educators.

Additionally, we can seek to increase the amount of time allocated for field experience within our secondary program. Thus, working with MTE-Partnership provided insights as to how other institutions address this concern, and provided models for us to emulate.

Moreover, declining enrollments have implications on our means to recruit and retain mathematics teachers. Hence, we need to reflect on means to support individuals who have a desire to pursue a career in mathematics education.

Panelist: Mark Ellis

California State University, Fullerton MTE-Partnership Team Summary

California State University, Fullerton (CSUF) is part of the 22-campus teacher preparation network of the CSU system, which also comprises the CSU MTE-Partnership team. CSUF has a rich local context within the partnership. The local work we have done has helped in a bidirectional sense—we have been able to secure additional funding and then use that funding (e.g., S.D. Bechtel, Jr. Foundation) to develop more partnerships and collaborations.

Importantly, though the MTE-Partnership is focused on the preparation of secondary teachers of mathematics, we have expanded that to include the work of preparing and supporting teachers of mathematics K–12. Through this work, we have been able to envision teacher preparation development as a continuum over time instead of isolated incidences of learning. Through the Bechtel Foundation grant, CSUF developed a shared vision within their own institution and in partnership with three local school districts that allowed for more explicit conversations across the local partnership, especially focused on the qualities of a well-prepared teacher of mathematics and the practices of mathematics teachers who support each and every K–12 student with learning mathematics.

One important tool that is now used across credential-program methods coursework and field observations, as well as within district partner professional learning work, is the Mathematics Classroom Observation Protocol for Practices (MCOP²; Gleason, Livers, & Zelkowski, 2015), a rubric grounded in the Standards for Mathematical Practice. This work will be further enhanced through a NSF Noyce Master Teaching Fellowship grant received in 2017 to work with 20 secondary teachers of mathematics (half of whom come from CSUF MTE-Partnership partner districts) to strengthen practice within their own classrooms. These 20 MTFs in the Advancing Teachers of Mathematics to Advance Learning for All (see <http://atmala.weebly.com>) will serve as mentors to CSUF teacher candidates using the co-plan, co-teach model and will support district efforts to transform mathematics teaching by developing and facilitating microcredential modules aimed at building proficiency with specific instructional skills related to culturally responsive mathematics teaching.

New faculty have been another important contributor to the success with program transformation. Since 2014, CSUF has hired four tenure-track mathematics education faculty within the departments of Mathematics and Secondary Education—with plans for a search for an Elementary Mathematics Teacher Education faculty in 2018–2019. From their start at CSUF, these faculty have been part of the MTE-Partnership conversations about elements of program transformation (e.g., co-plan/co-teach; district partnerships)—these became normalized conversations. Collaboration among mathematicians and mathematics educators across departments and colleges as well as between university and school-district partners came to be seen as the norm. A recent example of this came when discussing how to generate more enrollment in optional (but valuable) mathematics courses for future elementary and secondary teachers; in less than an hour the Departments of Mathematics, Elementary, & Bilingual Education and Secondary Education agreed to leverage existing funds to create a scholarship program for students who complete with a B- or better at least three of the four targeted optional courses. Having new deans in both colleges at the start of the 2016–2017 academic year aided in solidifying the program transformation because they understood the transformed program as something that was typical.

One set of challenges everyone has faced involves time: the time for planning; the time for implementing; the time for collecting data about the implementation; and the analysis of the data and revisions to the implementation model. For example, Plan-Do-Study-Act (PDSA) cycles take time. However, as this work becomes more routine and less novel, these actions are less burdensome. Another challenge remains the time required for some long-time faculty to embrace the transformed program as the new normal, but this will be helped in part through the efforts of two of the recently hired faculty in Mathematics, Alison Marzocchi and Roberto Soto, who received a SEMINAL grant to support their work on brining active learning strategies into Calculus courses over the next several years.

Zooming out to think about the CSU MTE-Partnership group, having the support of the statewide network of the 22-campus CSU team has helped address the challenge of time through leverage collective expertise and realizing there is strength in numbers. Through annual convenings at the CSU Chancellor's Office, faculty from throughout the CSU system have had opportunities to share strategies, resources, and form new collaborations that support teacher preparation efforts. Among the insights gained from conversations across the 22-campus

network was the realization that some campus credential programs did not require content specialists to do supervision of teacher candidates. When this surfaced in a survey generated by the CSU MTE-Partnership team, it provided faculty with substantive data to bring to local campus administrators to advocate for program changes. Collectively, it is essential that program quality not be negatively impacted by different contexts.

These convenings also have allowed us to have a louder voice within the CSU system. One example is the success with advocating for the addition of 16 mathematics-specific items to a statewide exit survey given to all credential program completers; hearing that through CSU MTE-Partnership mathematics teacher preparation faculty would be routinely examining such data for program improvement, the committee charged with updating the survey agreed to include these additional items. Data from this survey will allow faculty to look deeper into their programs both locally and across institutions using a recently launched data dashboard on the CSU's Educator Quality Center's website: <https://www2.calstate.edu/impact-of-the-csu/teacher-education/educator-quality-center/edq-dataview-dashboards/Pages/default.aspx>.

Panelist: Wendy M. Smith

NebraskaMATH STEP: Secondary Teacher Education Partnership

NebraskaMATH STEP joined the MTE-Partnership as a partnership among the three University of Nebraska campuses that have teacher preparation programs, along with the public school systems in those cities (Lincoln, Omaha, and Kearney). Prior to the MTE-Partnership, the Center for Science, Mathematics and Computer Education (est. 1990) had built a statewide partnership with public school districts and intermediary education agencies (called Education Service Units [ESUs]), focused on mathematics teacher professional development.

When Research Action Clusters (RACs) first formed, the Nebraska partnership joined the Active Learning Mathematics RAC (ALM RAC). Subsequently, members of the Nebraska partnership have also worked with the MODULE(S²) RAC, STRIDES RAC, Equity and Social Justice (ESJ) Working Group, and Transformations Working Group. Additionally, Nebraska has been engaged in local efforts to form a statewide Networked Improvement Community (NIC), to translate the work of the MTE-Partnership into local efforts to align programs with the new Standards for Preparing Teachers of Mathematics (AMTE, 2017).

Active Learning Mathematics RAC

The University of Nebraska-Lincoln (UNL) and University of Nebraska at Omaha (UNO) were founding members of the ALM RAC and received funds from the Helmsley Charitable Trust as part of MTE-Partnership. Funds on both campuses were used to launch a Learning Assistants (LAs) program (hiring undergraduates as assistants in freshmen-level mathematics courses to help facilitate active learning). Prior to ALM RAC, UNL was already working to improve freshmen-level courses below Calculus (Intermediate Algebra, College Algebra, Trigonometry, and College Algebra and Trigonometry). Prior to reforms, UNL had some measures of coordination, including: common syllabus, common exams, and common grading of common exams. Since 2011, changes at UNL have been extensive, including: hiring a full-time director of first-year mathematics to coordinate courses below Calculus; teaching courses in renovated rooms with movable tables/chairs and wrap-around whiteboards; hiring LAs; creating common lesson plans that incorporate active learning and group-work structures; adding time to courses without changing the credit hours (75-minute classes instead of 50-minute classes); and graduate student professional development (before-semester workshop and course during first year as an instructor of record).

In conjunction with these reforms, the Department of Mathematics began collecting (and gaining access to) extensive student data in order to measure student success, including passing rates, course-taking trajectories, and attitudes. Efforts have been very successful, raising passing rates (C or better) from around 60% to consistently around 80%. Additionally, efforts have expanded from Precalculus courses to Business Calculus, Calculus 1, and

Calculus 2, and a second professor of practice will begin in Fall 2018 to share in the coordination and mentoring duties. Future efforts include ongoing refinement of courses, exploring online exam options (not just multiple-choice items), and expansion of active learning structures into additional courses.

UNL is also a collaborative partner in the research grant SEMINAL: Student Engagement in Mathematics through an Institutional Network for Active Learning. Through this grant, the research team is seeking to understand the contextual and leadership factors that initiate and sustain institutional change in ways that increase student engagement and success in freshmen-level mathematics.

MODULE(S²)

UNL also became active in MODULE(S²), with Yvonne Lai as a core member of the subset of the RAC that received a grant from NSF. Lai has led the efforts to create the algebra module, and she has piloted and assisted with other modules as well.

STRIDES

UNL has been involved with STRIDES, particularly focused on retention. Initial efforts were made to understand the support received and needed by teachers within the first three to five years of teaching. The UNL group has worked to develop measures and collect data related to these supports in order to develop induction programs.

Recent Efforts: Equity and Social Justice Working Group

UNL has recently been active in the ESJ working group. This work has focused on identifying the problem space related to preparing secondary mathematics teachers to work in diverse settings. Specifically, the working group has developed definitions for diversity, equity, and social justice, with UNL higher education and K–12 partners contributing to the definitions of diversity and social justice. In addition, this work has spurred more intentional conversations across UNL secondary math education faculty and faculty in multicultural education, and it has prompted more intentional work across our secondary mathematics education professional coursework (two methods courses, associated practicum, and student teaching and student teaching seminar). For example, NCTM (2014)'s *Principles to Actions* Access and Equity principle has become a focus in the first of two methods courses, is emphasized in the second methods course when students are in an associated practicum in a diverse school and is the main focus in the student teaching seminar. This seminar primarily focuses on access, equity, and identity. In addition to *Principles to Actions*, the course texts include Fernandes, Crespo, and Civil's (2017) *Access and Equity Promoting High Quality Mathematics Instruction Grades 6–8* and Aguirre, Mayfield-Ingram, and Martin (2013)'s *Impact of Identity in K–8 Classrooms: Rethinking Equity-Based Practice*. Throughout the professional sequence, prospective teachers are required to reflect on their own experiences learning mathematics and interrogate their assumptions about what it means to do mathematics and what that looks like for their students.

Recent Efforts: Statewide NIC

UNL has been part of MTE-Partnership's Transformations Working Group. In 2017–2018, NebraskaMATH STEP has grown in two directions: encompassing most of the 16 colleges and universities that prepare teachers in Nebraska and expanding to consider pre-service preparation of elementary teachers in addition to secondary teachers. These two changes were closely related; only UNL has a large enough student and faculty population to have separate elementary and secondary mathematics teacher preparation; in the other institutions, the same faculty may teach elementary or secondary mathematics and/or methods courses.

At the September 2017 statewide NCTM affiliate meeting, the existing NebraskaMATH STEP group convened to discuss this potential expansion. At a first meeting in October 2017, representatives from 11 of the 16 teacher preparation institutions, the Nebraska Department of Education, and five of the largest school districts met. In addition to mathematicians, mathematics teachers, and mathematics teacher educators, there were also

special education and English-language learner faculty and district personnel. The purpose of this meeting was to try to form a statewide NIC to work toward the new Association of Mathematics Teacher Educators' (AMTE) Standards for Preparing Teachers of Mathematics (2017). The 34 attendees were excited to work together toward these aspirational standards, with UNL providing leadership and logistical support.

After an overview of the NIC process, the group brainstormed the problem space and then had discussions to determine priorities. Working groups formed around each priority: math dispositions, teacher preparation programs, clinical experiences/cooperating teachers, and partnerships. The overall mood of the group was excitement to be collaborating across institutions, particularly on the part of K–12 personnel, who in the past have not been a large part of the conversation about improving teacher preparation. The colleges and universities have a fair amount of rivalry, because most are recruiting from the same pool of in-state students, and the state schools are often forced to compete with one another for state resources. Faculty and district personnel were glad to be working directly with one another, without waiting for official institutional collaboration. We discussed possibilities such as joint programs where students could take classes from different campuses; however, such possibilities are far in the future after the working groups make some progress.

The math dispositions group wanted to better understand the attitudes of future teachers in our programs, so we developed and piloted a survey in winter 2017–spring 2018. The results of the open-ended items were used to develop some word-clouds to represent the responses. These word clouds then were used for program representatives to discuss how programs might be revised to develop more positive attitudes toward mathematics, particularly for prospective elementary teachers.

The teacher preparation programs group was designed to survey the preparation programs in the state to determine the status quo. Depending on many factors, programs at different institutions are quite different in terms of the number and sequence of courses and field experiences. As a first step toward borrowing the best from each institution, there was a desire to know and understand what each program does. Conversations included people sharing strengths of their programs. For most people, this was the first time there was an organized way to learn about what other Nebraska programs are doing. Most programs deal with small numbers (one to five secondary mathematics teachers graduating in a year), which leads to particular challenges in offering courses specific for future mathematics teachers.

The clinical experiences/cooperating teachers working group was focused mostly on developing some type of shared cooperating teacher training (likely online); at present, the most any cooperating teacher is required to do in terms of training is to attend a district-sponsored orientation put on by the human resources department and is more about nuts-and-bolts (and things like sexual harassment) and not about how to mentor a novice mathematics teacher. The working group's first steps are to gather data from stakeholders to develop a shared vision for high-quality mentor teachers in mathematics. Following that, school personnel and university faculty plan to work together to design workshops for mentor teachers.

The partnership's working group decided to work on leveraging expertise on both sides of the K–12—higher education partners, and develop more opportunities to converse, including at the Nebraska Association of Teachers of Mathematics, the state administrator days, and other local conferences and workshops. A first step is to develop “conversation starters” to help get partnerships started. This group also discussed partnerships within and across higher education, particularly how to connect math and education departments, as well as special education and English-language learning. The working group noted that while the bureaucratic processes are prohibitive, establishing strong partnerships is worth doing in order to better prepare and support novice mathematics teachers.

A subset of the overall state group met in conjunction with the M4 conference (a mathematics education conference for Nebraska, Iowa, Kansas, and Missouri) in March 2018. Working groups reported on progress and next steps. The group next plans to meet in September 2018, at the state's Nebraska Association of Teachers of Mathematics meeting.

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Transformations Working Group

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From its inception, the Mathematics Teacher Education Partnership (MTE-Partnership) has had as its goal of transforming secondary mathematics teacher preparation in alignment with the Common Core State Standards and other rigorous standards. More recently, the goal has expanded to encompass the Standards for Preparing Teachers of Mathematics (Association of Mathematics Teacher Educators [AMTE], 2017). As the MTE-Partnership adapted the Networked Improvement Community (NIC) design (Bryk, Gomez, Grunow, & LeMahieu, 2015), two aims were set: (a) increase the supply and (b) increase the quality of secondary mathematics candidates, and a set of four primary drivers was identified. The MTE-Partnership disaggregated its work into five Research Action Clusters (RACs) addressing various aspects of the primary drivers, thus allowing the MTE-Partnership to “accelerate learning” through the power of the network (p. 141). This separation, however, results in a conundrum: Each partnership team generally is only involved in one (or perhaps two) of these RACs—meaning that they are addressing only some of the areas of critical need. To fully meet the aim of the MTE-Partnership, teams must shift toward more holistic program transformation and integrate the work of the partnership across multiple RACs into their local improvement efforts. However, accomplishing this integration will, in many cases, raise a number of significant challenges, including capacity and human capital, issues with the “will” to improve mathematics teacher preparation across stakeholder groups, and issues with institutional resources and support structures.

The Transformations Working Group was formed in Spring 2016, including members nominated by teams across the MTE-Partnership, with the following charge: “To establish a foundation for the MTE-Partnership’s strategic focus on overall transformation of secondary mathematics teacher preparation programs.” The approach proposed by the MTE-Partnership Planning Committee was that the Working Group design ways to support teams in creating “strategic pathways” to scale up incorporation of the MTE-Partnership’s improvements, with the ultimate aim of comprehensive program transformation with a focus on building capacity and infrastructure, collaboration with K–12 and other stakeholders, and cross-team collaboration. The group has explored the literature on institutional change (e.g., Corbo, Reinholz, Dancy, Deetz, & Finkelstein, 2016; Elrod & Kezar, 2016), conducted several surveys of the membership, and done extensive brainstorming on how to best support transformational change across the MTE-Partnership teams. In Spring 2018, the group submitted a proposal to the National Science Foundation to study five cases of program transformation by five of the local MTE-Partnership teams, while also testing potential knowledge generation and management systems (KGMS). An effective KGMS will better support scaling up and sharing knowledge associated with local transformation efforts.

Table 1

Active Members of the Transformation Working Group

Pier Junor Clarke, Georgia State University	Margaret Mohr Schroeder, University of Kentucky
Mark Ellis, California State University, Fullerton	Jennifer Oloff-Lewis, California State University, Chico
Dana Franz, Mississippi State University	Robert Ronau, National Science Foundation
Judy Kysh, San Francisco State University	Wendy Smith, University of Nebraska-Lincoln
W. Gary Martin, Auburn University	Marilyn Strutchens, Auburn University
	Diana Suddreth, Utah State Office of Education

Analysis of the Problem

Even as mathematics teacher educators are working to improve aspects of their teacher preparation programs, they may have difficulty enacting changes needed to transform their programs in ways aligned with the MTE-Partnership Guiding Principles and AMTE (2017) standards. As AMTE notes, “these standards are aspirational... rather than describing minimal levels of competency needed by beginning teachers” (p. xi).

Aim

Based on its analyses of the problem space, the following aim is proposed to guide the emerging work in this area:

In order to attain the overall MTE-Partnership aim (“gold standard” as expressed in its Guiding Principles and number of candidates produced), *N* teams will be engaged in an *explicitly defined* continuous improvement process of overall transformation of their secondary mathematics teacher preparation programs by June 2019, in collaboration with other teams engaged in that process.

Several notes are made to better understand this statement:

- “Program” as used here includes the continuum from recruitment of future teachers of mathematics, undergraduate content coursework, early fieldwork experiences, methods coursework, and fieldwork with mentor teachers in partner school districts, to early career induction support.
- To meet the condition, there must be an explicit plan for improvement for the program, including methods of documentation.
- Continued attention is needed as to whether the Guiding Principles sufficiently define the gold standard, particularly with respect to induction, in light of AMTE’s new standards; see www.amte.net/standards.
- *N* will initially be somewhat small (5), but then expand to be more aggressive (perhaps up to 80), and then ultimately encompass all MTE-Partnership teams.

Driver Diagram

A driver diagram is a tool that visually represents a group’s working theory of action to drive program improvement. The driver diagram creates a common language and coordinates the effort among the many different individuals joined together in solving a shared problem; see Figure 1. The first column includes the primary drivers, a representation of a community’s hypotheses about the main areas of influence necessary to advance the improvement aim. The second column includes the secondary drivers, a small set of system components that are hypothesized to activate each primary driver. The final column includes change ideas, alterations to a system or process that are to be tested through a Plan-Do-Study-Act (PDSA) cycle to examine their efficacy in improving some driver(s) in working theory of improvement (see <https://www.carnegiefoundation.org/resources/learning-to-improve-glossary/> for more information). The

Transformation Working Group sees its driver diagram as helping to provide a common vision for program transformation efforts. Each local program may find the relative importance and need of each driver to be different, but likely will need to attend to all of the drivers across program transformation efforts.

Current Progress

Over the past year, the Working Group has engaged in two primary lines of activity: (1) engaging stakeholders, and (2) building a system to generate and manage knowledge across the MTE-Partnership.

Engaging Stakeholders

The local partnership teams represented in the Transformations Working Group met regularly across the past year (via video-conferencing). We collectively chose to focus on the first change idea:

Engage stakeholders in developing common vision, values, and beliefs—important to get all stakeholders to buy-in, to develop a shared urgency for the need for transformation.

Each team initiated PDSA cycles to track their progress in addressing this change idea. Having regular group meetings helped promote accountability: Knowing the working group would be meeting helped members make time for transformation efforts in between meetings and to remember to complete brief PDSA cycle reports. Regular conversations also helped members to learn from one another's efforts. Whole program transformation efforts can be daunting; members of the Transformations Working Group value starting small and have come to see that even setting a meeting with relevant stakeholders can be progress. For example, setting up a meeting with a new dean, and sharing the local team's vision and progress toward program transformation, thus getting the new dean on board with efforts, is a valuable step in the transformation process. As another example, convening a set of local stakeholders involved in secondary mathematics teacher preparation supports progress by building channels of communication. These first steps may seem small but building a foundation of a common vision among a broader range of stakeholders provides a launching point for transformation efforts.

Knowledge Generation and Management System (KGMS)

A second major change idea identified by the working group is the development of a system to manage the generation and management of knowledge across the RACs and working groups of the MTE-Partnership. This is essential to achieving the working group's aim and the MTE-Partnership goal of program transformation, by helping to manage the creation of emerging products and approaches developed by the RACs so that these are accessible across the partnership teams. "By formalizing the identification, capture, and organization of practical knowledge, a hub can accelerate the spread and use of the products of past improvement research" (Bryk et al., 2015, p. 158).

Over the past year, the Transformations Working Group spent considerable time investigating potential KGMS platforms. The group found quite a bit of research (mostly in the business sector) on knowledge management systems. However, such systems tend to focus on creating a library of resources. Our vision is a dynamic system that is not only a repository of collective knowledge, but also supports the generation and propagation of knowledge. As users try strategies in the KGMS, they will further add to the knowledge base about that strategy, thus enriching the information known about the strategy for the next user. Thus, a KGMS platform needs to not only store and organize files, but also allow discussion and iteration of these files. Based on our research, we seek a KGMS with the following features:

- Has an accessible front-end to support both retrieval and sharing functions;
- Includes a system to organize and codify content, such as tagging, to increase usefulness in retrieving information;
- Supports knowledge sharing through integrating editing, annotating, and commenting;
- Includes levels of access to support maintenance of standards of quality;
- Supports tools for collaboration, such as threaded discussions or chats; and
- Integrates with and captures in-person collaborations.

The working group has submitted a proposal to the National Science Foundation (NSF) to support work on program transformation, particularly the development of a KGMS. Funding for PDSA cycles to try out several platforms is part of that proposal, which supports trying out several different platforms to evaluate their relative usefulness. The top potential platforms under consideration are Trellis (MTE-Partnership's current platform), Google Sites/Google Drive, and Open Canvas. We suspect no single platform will suffice and meet the needs of all local partnership teams. And, if a team already has a functioning collaborative space online, we will not ask them to move over to a new system unless there is significant value added.

Next Steps

The Transformation Working Group provided several opportunities to engage teams in discussion about program transformation at the 2018 MTE-Partnership Conference:

1. A working dinner included remarks from Susan Elrod, a leader in thinking about institutional change (cf. Elrod & Kezar, 2017), in conjunction with Marilyn Strutchens, who focused on equity issues.
2. A plenary session featured a panel presentation by five representatives of local teams working on different dimensions of program transformation. Each panelist shared a challenge faced, and how that challenge was addressed.
3. A discussion session was organized Monday evening to provide interested team members with an opportunity to discuss the work that has been done by the working group and prospects for participation in program transformation.

People interested in launching program transformation efforts for their local program are encouraged to use a common aim and driver diagram to help position initial change strategies; the driver diagram developed by the Transformation Working Group (see Figure 1) may be a useful resource for local teams in thinking what they might do within their local context. The discussion of a process for improving mathematics teacher preparation in the AMTE standards (2017, pp. 164–165) may also be of use. Change agents are encouraged to start small, and document efforts via PDSA cycles. Finally, change agents can encouraged to participate in monthly video-conference meetings with the Transformations Working Group, to share progress and learn from one another.

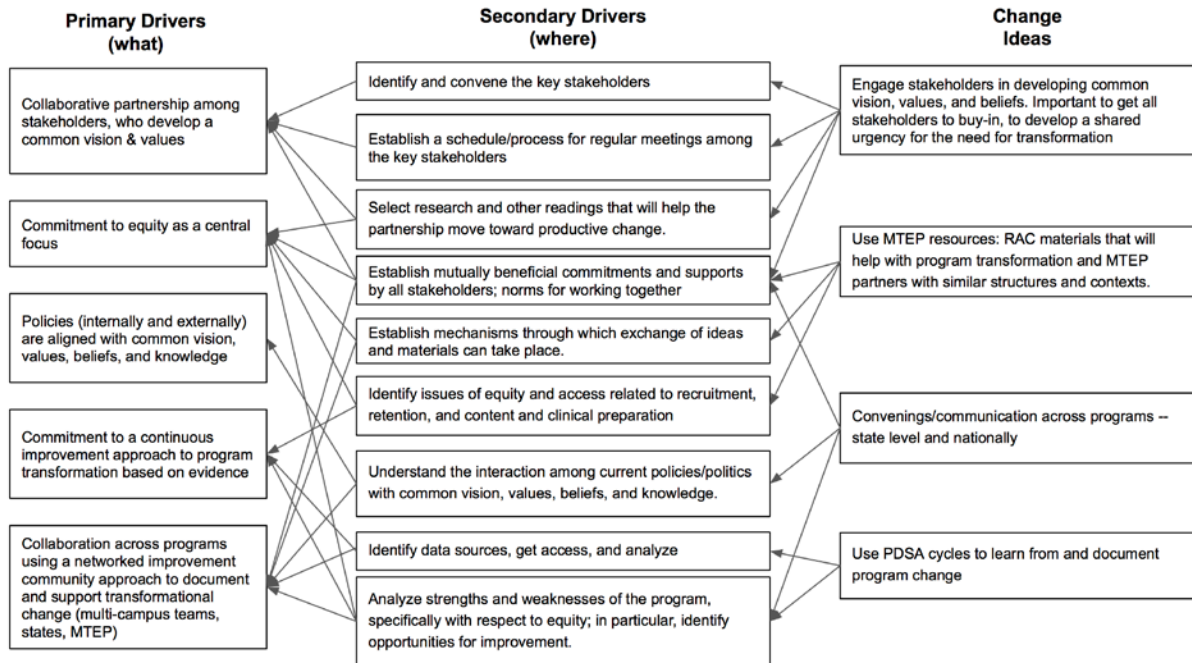


Figure 1. Driver diagram to guide progress toward the aim of program transformation.

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Equity and Social Justice Working Group

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Secondary mathematics teachers are charged with ensuring that each and every student becomes proficient in the state-mandated high school mathematics content (Association of Mathematics Teacher Educators [AMTE], 2017). Yet academic success for all high school mathematics students remains a persistent challenge (National Council of Teachers of Mathematics [NCTM], 2018). Some of these challenges are structural (NCTM, 2018), but some lie in the sociocultural realm. For example, teachers are tasked with improving the mathematical identities of students (sociocultural), yet many students are tracked into course sequences that do not offer access to an appropriate curriculum (AMTE, 2017).

A well-prepared beginning secondary mathematics teacher embraces the goal for academic success for each and every student, and also understands how social, historical, and institutional contexts affect teaching and learning (AMTE, 2017). As the members of the MTE-Partnership consider the preparation of future secondary mathematics teachers, we must respond to these challenges to produce knowledgeable and committed advocates for each and every child.

Role of the Equity and Social Justice Working Group

In a work session following the Sixth Annual MTE-Partnership conference, members of the Equity and Social Justice Working Group (ESJWG) began to lay out key drivers and change ideas toward the goal to produce secondary mathematics teachers who were knowledgeable and committed advocates. This session led to a statement of our improvement aim: Pre-service teachers' (PST) equity-driven sociopolitical dispositions and knowledge and use of equitable teaching practices will improve over the course of their teacher preparation program. This aim has two foci, for the PST to see themselves as advocates and for them to have the tools to achieve that goal. Along with this aim statement, a first draft of a complete driver diagram was completed in early 2018; see Figure 1. The driver diagram states our aim and the primary drivers necessary to advance the aim. The secondary drivers describe the system components that we hypothesize will activate the primary drivers. Finally, the change ideas, as listed, are initial improvement thoughts on processes to be tested on the associated drivers through Plan-Do-Study-Act (PDSA) cycles.

After settling on our own driver diagram (i.e., theory of change), ESJWG next reflected on its role with the MTE-Partnership. The ESJWG was formed to support the MTE-Partnership to fully attend to equity and justice challenges in preparing secondary mathematics teachers and to support dimensions of equity within the work of each RAC. Thus, ESJWG buttresses the five current primary drivers of the MTE-Partnership: Transforming Programs, Creating a Vision, Improving Clinical Preparation, Increasing Content Knowledge, and Improving Recruitment and Retention. Furthermore, equity and justice issues are underlying values in all elements of the preparation of secondary mathematics teachers; thus, Equity and Social Justice must stand apart as a secondary driver distinct from the other RACs. With these dual roles in mind, ESJWG proposes a revised MTE-Partnership driver diagram, as shown in Figure 2.

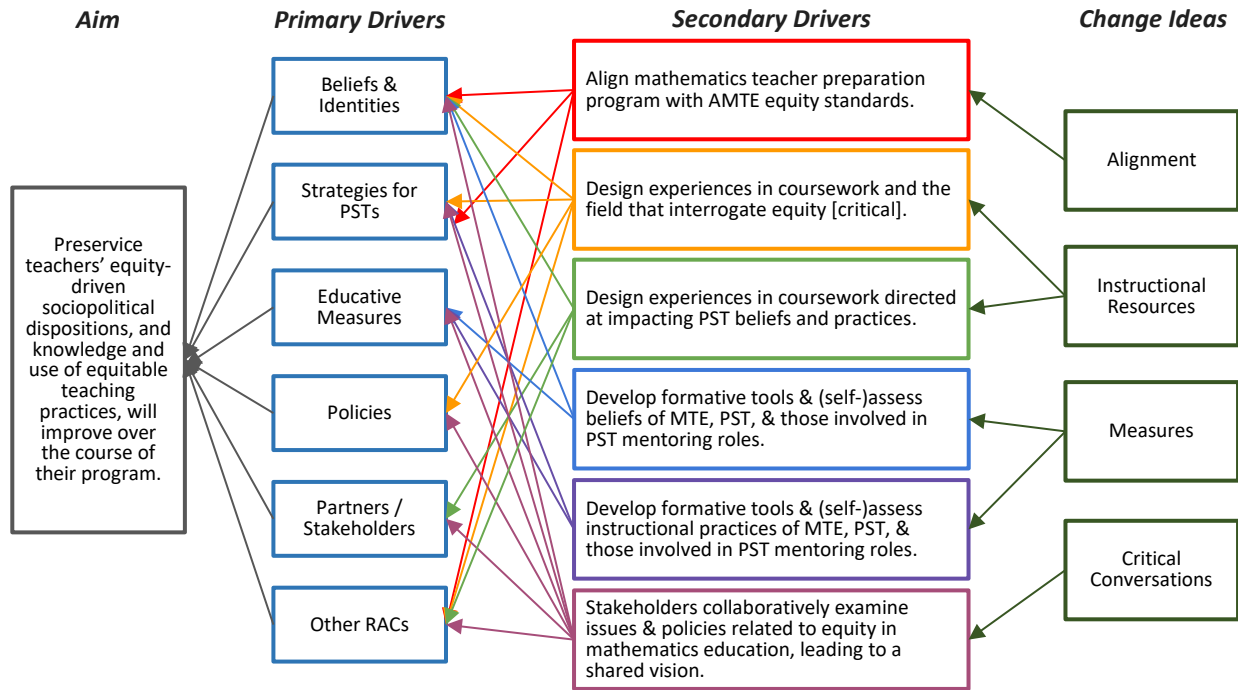


Figure 1. ESJWG driver diagram.

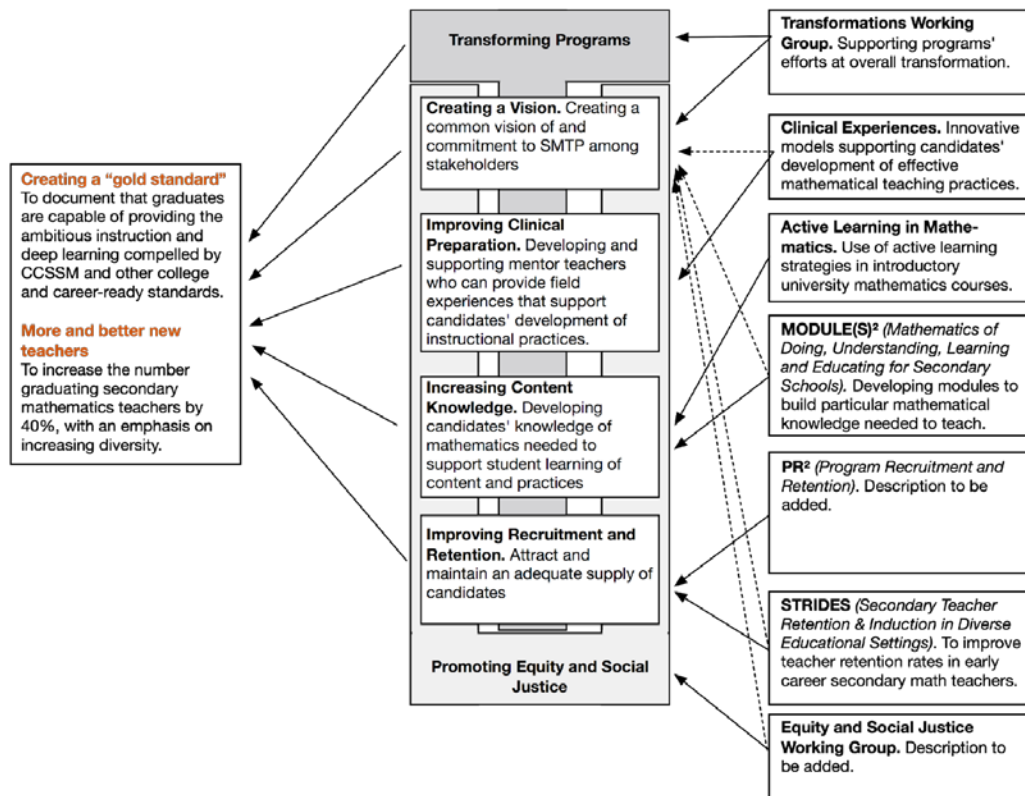


Figure 2. Proposed ESJWG revision to the MTE-Partnership driver diagram.

With the aim identified, and drivers established, the ESJWG was also able to initiate some PDSA research cycles to begin to tackle the challenge prior to the 2018 conference. Two PDSA cycles will be discussed here because of their presence during the conference. One need that emerged from the MTE-Partnership members was to define and develop a shared meaning for some terms commonly used in the equity parlance. Shortly after its inception, the ESJWG began developing definitions and a structure to communicate these in a way that was useful to the broader membership. Currently, we have an initial draft of these definitions and have received feedback from several MTE-Partnership members as well as a group of PSTs (Males & Males, 2018). During the summer of 2018, each small team is refining definitions, to be shared with the MTE-Partnership Research Action Clusters (RACs) in the fall.

A second PDSA cycle emerged from a challenge posed in our aim: How do we know if PSTs' dispositions and use of equitable teaching practices have improved during their program? At present, there do not exist any well-accepted tools to measure the equity disposition or to examine their knowledge/ability to implement equitable pedagogies. However, there are certainly resources to build upon or adapt. For example, the EQUIP tool (Reinholz & Shah, 2018) shows promise to examine equitable discourse patterns in the classroom. A subcommittee of the ESJWG is examining the options to utilize this tool to help measure our aim.

During the conference, the subcommittee held a conference call with Niral Shah, to further understand the potential for our use, and explore details of being able to begin running tests. We learned that the EQUIP tool is a web-based application (app) that has great flexibility for observing video and tagging instances of user-defined observables. In addition to the ability to code a video, the app offers some exceptional opportunities to provide insightful data analysis. The tool seems to have potential for our use for the following reasons:

1. A beta version will be released at the end of Summer 2018, and the developers are interested in partners to pilot the tool with teachers and study how teachers use it to inform their practice.
2. The tool allows for flexibly defining the variables you wish to code, facilitates the data collection, and creates data visualizations to explore.
3. It fits well within the PDSA cycle framework.
4. We could use it as a way to generate evidence across different sites about the dimensions of equity we want to focus on in classroom interactions using shared variables.
5. We could imagine it fitting in the variety of contexts across the MTE-Partnership (undergraduate classrooms, pre-service field experience, student teaching, etc.).

We plan to implement PDSA cycles soon to examine the usefulness of this tool for our measures. Our next important step will be designing the items to code in a video.

Work Completed at the Conference

In addition to this conference call, there were four activities of the conference to discuss: reactions to our poster session, work on the monograph, our two-hour discussion session, and an initial analysis of the data that came from that. First, some context about the manner in which the members of ESJWG engaged in the conference. Because each member was formerly or remains presently an active member of one RAC, most ESJWG members attended their RAC working time throughout the conference. However, a few of us have decided to make the ESJWG our main home, so we worked during the RAC times on the aforementioned four activities. It should be noted that members of the ESJWG who participated in their RACs continued to ensure that equity issues remained a focus for the RAC. Evidence of this appears in the reports of each of the other RACs.

First, a noteworthy activity of the ESJWG was to present an update at the conference of our work during the past year. For us, this was primarily a report of our problem analysis resulting in fishbone and driver diagrams.

We also noted the initial work of the definitions project and a few early PDSA cycles. What was particularly interesting was to reflect on the comments and questions we received, some of which are reported here:

1. Does ESJWG need to become a RAC? Many of the items in the drivers or fishbone diagram are being tackled by the other RACs.
2. Our work seems to emphasize equity, not social justice. Why might that be; what does that mean? Is social justice the action behind or driver for equity?
3. There seems to be overlap in the definitions of equity, diversity, and social justice. There may be value in presenting these as a Venn diagram.
4. Our definitions may need a 30,000-foot view, because as we get close to the ground, local contexts become important in the meanings.
5. Maybe “social justice mathematics” is different from “mathematics for social justice.”
6. Are these two different things: seeing self as mathematician / I do math, versus using math to critique my world?

These responses will be taken up in the coming year.

Some of our working time was dedicated to organizing for completion of the monograph chapter, due at the end of July. As the ESJWG planned for the chapter, it was decided that the primary emphasis would be on digging into the themes that emerged from the work to identify the problem space, i.e., the bones of our fishbone diagram. The author team each tackled a brief review of the literature on these bones, to be completed by the conference time. The chapter’s lead authors examined these contributions and identified an outline for the chapter.

The most significant project during the conference was a two-hour Equity and Social Justice discussion session for MTE-Partnership conference attendees. The agenda was developed the month prior by the ESJWG, with an agreement to focus first on sharing out what Aguirre, Mayfield-Ingram, and Martin (2013) defined as equitable teaching practices (see Appendix). We thought this would provide attendees with new ideas and specific direction for challenging themselves to improve their own teaching of PSTs and/or developing the teaching strategies of PSTs.

Second, we presented the equity and justice problem space related to the preparation of secondary mathematics teachers (see Figure 3) developed in the work of the ESJWG and ask attendees to identify where their RAC was working. The categories, “bones,” of our fishbone diagram included: definitions, policies, disconnections between school partners and higher education, expertise, resources, what does “it” (equity) look like, mathematics is not a space where diverse ways of knowing and learning are valued, PSTs do not identify as agents of change toward a more just society, deficit discourses, courageous conversations, and diversity of people. We felt this not only would help attendees reflect on their work through the broad perspective suggested in the fishbone, but also provide us with some information about the terrain in which RACs were already working. Their feedback would highlight large spaces that needed attention and identify potential work for the ESJWG.

A final project of the ESJWG at the conference was to conduct an initial analysis of the data collected during the second phase of the two-hour discussion session. Specifically, we tabulated all responses from RACs pairing their current work with our fishbone diagram. Each category on the ESJWG fishbone was addressed by at least one RAC. However, numerous subcategories were not marked. A few other observations and responses made in our nascent analysis of the fishbone diagram data are included below:

- The fishbone utilizes deficit language. Several participants had difficulty with deficit language that might have been addressed by a more explicit explanation of the tool.

- Conversations about equity and social justice can make people uncomfortable; it's important to support them in being ok with not being where they anticipate they should be.
- Some RAC members feel that they do not have enough knowledge of equity and/or social justice to include it in their work.
- RACs may be beginning to consider equity and justice issues in their work, and in many cases are ready for support to make it more effective.
- There is uncertainty about what it means to address issues of diversity, equity, and social justice within the RACs.

This initial data collection provides us some starting points for the progression of the working group, especially in our responsibility to serve as liaisons to the RACs.

We concluded the conference considering how this information collected during the discussion session might inform the next steps of the ESJWG. Initial thoughts included:

- ESJWG should examine the responses from the discussion forum and structure future work by identifying work unique to ESJWG and RAC liaison work.
- Utilize the RAC liaison to (a) better understand what each sticky note said, and (b) get more complete responses.
- Send summary of sticky notes to each RAC; collect feedback, refinement, and questions.
- Utilize the liaison role to support RACs with tensions between "equity" and their aims.
- Consider a project focused on educating MTE-Partnership members, per their request.

Reflection on the discussion session and analysis of each RACs reflection on their work provided the ESJWG members opportunity to begin to identify needs of the MTE-Partnership and shape our future work.

Moving Forward

The ESJWG was initially a collection of active RAC members nominated to form this working group. The seventh annual conference marked a time when this by-invitation-only group was ready to welcome new members. Because the ESJWG is not a RAC, we do not need team memberships and could allow individuals into our organizational structures. Since an important element of the ESJWG is to maintain close ties to each of the RACs, we invited new members to participate in one of two ways, as a RAC liaison or an active member. The option to serve as a liaison allowed interested participants to maintain their ties with their RAC while participating in the work of the ESJWG. An updated membership list is provided in Table 1. When a RAC is listed, that person remains an active member of that RAC, and serves as a liaison to the ESJWG. Members listed without a RAC are active members of ESJWG, and our new members are noted with an asterisk.

Table 1

Members of the MTE-Partnership Equity and Social Justice Working Group

Member	Institution	RAC
Keisha Albritton	University of South Florida	
Cynthia Anhalt*	University of Arizona	MODULE(S ²)
Brittney Black*	North Carolina State University	
Cyndi Edgington	North Carolina State University	Clinical
Ryan Seth Jones	Middle Tennessee State University	PR ²
Nancy Kress	University of Colorado	ALM
Brian R. Lawler	Kennesaw State University	

Josh Males	Lincoln Public Schools	
Lorraine Males	University of Nebraska Lincoln	
Charmaine Mangram	University of Hawai'i at Mānoa	Clinical
Cathy Martin*	Denver Public Schools	
Julie McNamara	California State University East Bay	PR ²
Farshid Safi	University of Central Florida	
Wendy Sanchez	Kennesaw State University	
Ruthmae Sears	University of South Florida	Clinical
Jami Stone	Black Hills State University	Clinical
Jeremy F. Strayer*	Middle Tennessee State University	MODULE(S ²)
Marilyn E. Strutchens	Auburn University	Clinical
Fred Uy	California State University Chancellor's Office	
Matt Voigt*	San Diego State University	ALM
Patrice Waller*	California State University Fullerton	Clinical
Charity Watson*	Florida International University	ALM
Travis Weiland*	Appalachian State University	

For the 2018–19 academic year, we plan for the work of the ESJWG to include:

- Monthly meetings of the *active* working group members, to allow for updates on PDSA work including discussion of challenges, and predetermined topics as necessary.
- Some of these monthly meetings will focus on interfacing with the other RACs. All *liaisons* will also be invited to these meetings, roughly once every three months.
- PDSA cycles with priority placed on the definitions and measures work.
- Revision and refinement of the driver diagram towards the end of the year.

We expect to attract a few more members and liaisons during the year. The focus on interfacing with the other RACs marks a significant shift in the work of ESJWG to this point. We look forward to supporting the MTE-Partnership community toward achieving the MTE-Partnership Guiding Principles (2014), both in direct relationship to the community and through a research agenda of our own.

References

- Aguirre, J. M., Mayfield-Ingram, K., & Martin, D. B. (2013). *The impact of identity in K-8 mathematics: Rethinking equity-based practices*. Reston, VA: National Council of Teachers of Mathematics.
- Association of Mathematics Teacher Educators. (2017). *Standards for preparing teachers of mathematics*. Raleigh, NC.
- Males, J., & Males, L. (2018). Examining prospective mathematics teachers' reactions to definitions of diversity, equity, and social justice. In W. M. Smith, B. R. Lawler, J. F. Strayer, & L. Augustyn (Eds.), *Proceedings of the seventh annual Mathematics Teacher Education Partnership conference* (p. 133). Washington, DC: Association of Public and Land-grant Universities.
- Mathematics Teacher Education Partnership. (2014). *Guiding principles for secondary mathematics teacher preparation*. Washington, DC: Association of Public and Land-grant Universities.
- National Council of Teachers of Mathematics. (2018). *Catalyzing change in high school mathematics: Initiating critical conversations*. Reston, VA: Author.
- Reinholz, D., & Shah, N. (2018). Equity analytics: A methodological approach for quantifying participation patterns in mathematics classroom discourse. *Journal for Research in Mathematics Education*, 49(2), 140–177.

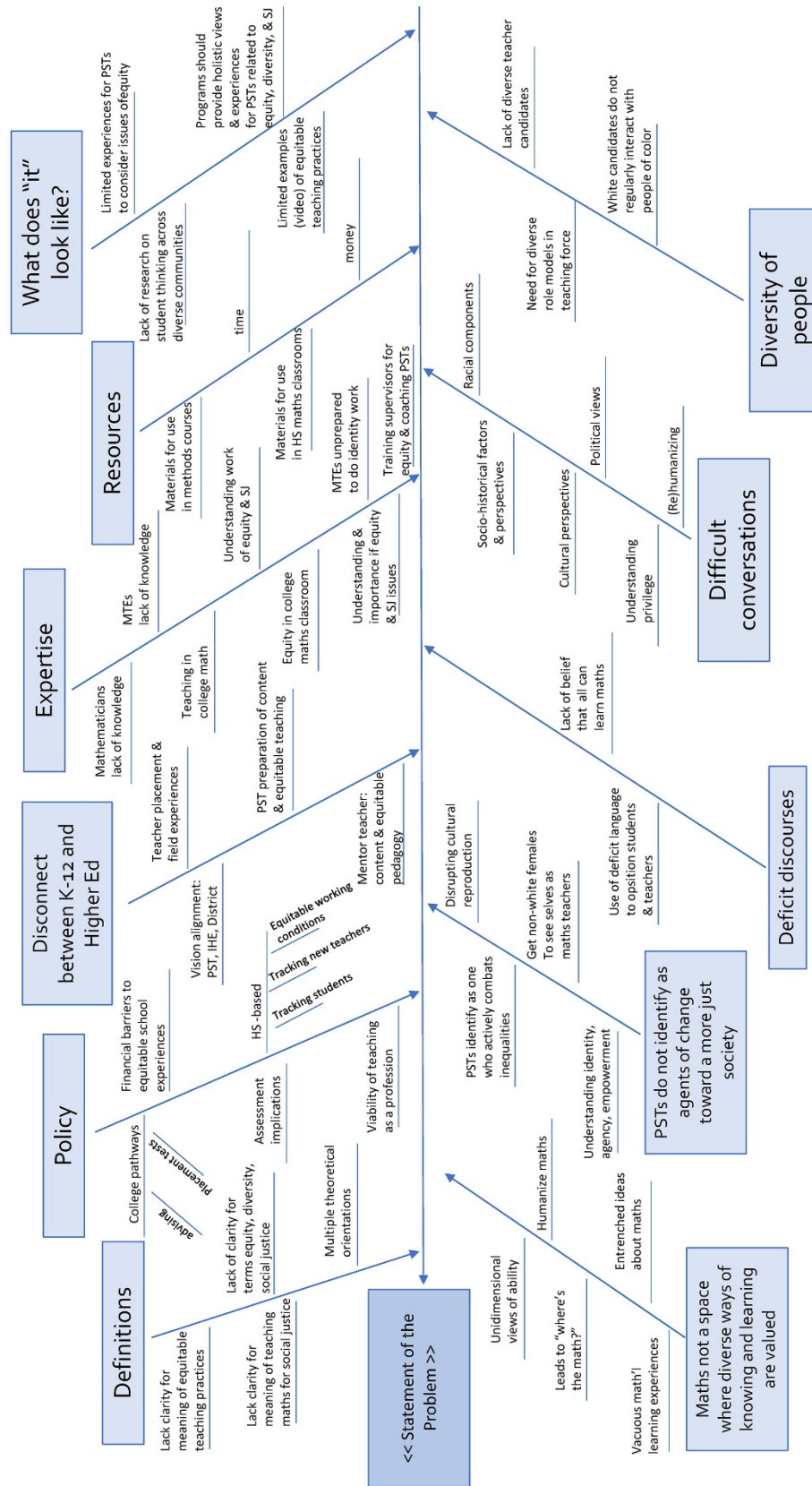


Figure 3. Fishbone diagram, identifying the major challenges toward the ESJWG goal.

APPENDIX

Five Equity-Based Practices in Mathematics Classrooms

Aguirre, Mayfield-Ingram, & Martin (2013)

Go deep with mathematics

- Support students in analyzing, comparing, justifying, and proving their solutions.
- Engage students in frequent debates.
- Present tasks that have high cognitive demand and include multiple solution strategies and representations.

Leverage multiple mathematical competencies

- Structure student collaboration to use varying math knowledge and skills to solve complex problems.
- Present tasks that offer multiple entry points, allowing students with varying skills, knowledge, and levels of confidence to engage with the problem and make valuable contributions.

Affirm mathematics learners' identities

- Promote student persistence and reasoning during problem solving.
- Encourage students to see themselves as confident problem solvers who can make valuable mathematical contributions.
- Assume that mistakes and incorrect answers are sources of learning.
- Explicitly validate students' knowledge and experiences as math learners.
- Recognize mathematical identities as multifaceted, with contributions of various kinds illustrating competence.

Challenge spaces of marginality

- Center student authentic experiences and knowledge as legitimate intellectual spaces for investigation of mathematical ideas.
- Position students as sources of expertise for solving complex mathematical problems and generating math-based questions to probe a specific issue or situation.
- Distribute mathematics authority and present it as interconnected among students, teacher, and text.
- Encourage student-to-student interaction and broad-based participation.
- Draw on multiple resources of knowledge (math, culture, language, family, community).
- Make intentional connections to multiple knowledge resources to support mathematics learning.
- Use previous mathematics knowledge as a bridge to promote new mathematics understanding.
- Tap mathematics knowledge and experiences related to students' culture, community, family, and history as resources.
- Recognize and strengthen multiple language forms, including connections between math language and everyday language.
- Affirm and support multilingualism.

RESEARCH ACTION CLUSTER REPORTS

Clinical Experiences

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Teacher preparation programs face significant challenges in providing secondary mathematics teacher candidates with quality clinical experiences. The problem is two-fold:

1. There is an inadequate supply of quality mentor teachers to oversee clinical experiences. Too few teachers are well-versed in implementing the Common Core State Standards for Mathematics (CCSS-M; Common Core State Standards Initiative, 2010), and teachers are especially inexperienced with embedding the standards for mathematical practice into their teaching of content standards on a daily basis. Further, many veteran teachers do not implement the mathematics teaching practices as discussed in *Principles to Actions* (National Council of Teachers of Mathematics [NCTM], 2014) on an ongoing basis.
2. Bidirectional relationships between the teacher preparation programs and school partners in which clinical experiences take place are rare. Such relationships that reflect a common vision and shared commitment to the vision of the CCSS-M and other issues related to mathematics teaching and learning are critical to the development and mentoring of new teachers.

The work of Clinical Experience Research Action Cluster (CERAC) encompasses a number of the principles and principle indicators from the Mathematics Teacher Education Partnership (MTE-Partnership) Guiding Principles, including fostering partnerships between institutions of higher education, schools and districts, and other stakeholders such as state departments of education and is focused on preparing teacher candidates who promote student success in mathematics, as described in CCSS-M and other college- and career-ready standards. In the CERAC, higher education faculty and partner school districts and schools work together to actively recruit, develop, and support in-service master secondary mathematics teachers who can serve as mentors across the teacher development continuum from pre-service to beginning teachers. Moreover, the CERAC helps to ensure that teacher candidates have the knowledge, skills, and dispositions needed to implement educational practices found to be effective in supporting all secondary students' success in mathematics as defined in the CCSS-M and other college- and career-ready standards.

The CERAC consists of 24 university-led teams, each consisting of at least one mathematics teacher educator, a mathematician, and a school partner. The CERAC is divided into three sub-RACs based on the three types of field experiences that we are implementing to meet the goals that we set forth in our primary drivers and our aim statement. The sub-RACs are: Methods, Paired Placement, and Co-Planning and Co-Teaching. Each sub-RAC is implementing Plan-Do-Study-Act (PDSA) cycles based on their goals and objectives. Teams work together via conference calls, email, and the Trellis platform. They use Dropbox, Google Drive, and Trellis as a way of sharing files and materials. Additionally, they have held face-to-face meetings as a RAC that included breakout meetings for sub-RACs. The sub-RACs have overlap areas that drive and focus the RAC, such as the emphasis on the mathematics teaching practices (NCTM, 2014) and other equitable teaching practices, professional development for mentors related to the CCSS-M and 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 has developed its own specific research questions.

Update on the Collective Work of the RAC

One of the major accomplishments of the clinical experience RAC since the 2017 MTE-Partnership conference was the receipt of funding for a proposal to the Engaged Student Learning, Design or Development and Implementation (level 2) of IUSE of the National Science Foundation. The project is led by principal investigators from Auburn University, the University of South Florida, and the Association of Public and Land-grant Universities (APLU). The NSF-IUSE grant, *Collaborative Research: Attaining Excellence in Secondary Mathematics Clinical Experiences with a Lens on Equity*, is implementing an improvement science study to answer the following question: How does a continuum of collaborative and student-focused clinical experiences, including co-planning /co-teaching and paired placement fieldwork models, impact pre-service teachers' equitable implementation of the Mathematics Teaching Practices (MTPs; NCTM, 2014) across multiple institutional contexts? The research will be conducted by a consortium of 24 universities, along with their school partners engaged in APLU's MTE-Partnership, which is currently developing and testing three alternative models for clinical experiences using a networked improvement community (NIC) design (Bryk et al., 2015). Throughout the 2017–2018 academic year, members of the RAC began implementing the project. During the 2018 MTE-Partnership conference, RAC members reflected on their data collection plan, discussed what they gleaned from the conference that could help them in ensuring that teacher candidates across the 24 teams are developing equitable teaching practices and other skills that the teacher candidates need in order to facilitate their student's mathematics growth. RAC members also discussed challenges related to the goals that they have set for themselves as a RAC and for the grant and found some solutions.

In addition to starting the work on the grant during the academic year, members of the RAC submitted two chapters to a handbook related to clinical experiences. The submissions are listed below:

- Yow, J. A., Waller, P., & Edwards, B. (2018, Accepted). A national effort to integrate field experiences into secondary mathematics methods courses. In T. Hodges & A. Baum (Eds.), *Handbook of research in field-based teacher education*. Hershey, PA: IGI Global.
- Strutchens, M., Sears, R., Whitfield, J., Lewis, J., Erickson, D., Brosnan, P., Conway, B., Junor-Clarke, P., Biagetti, S., Parrish, C., & Ellis, R. (2018, Accepted). Implementation of paired placement and co-planning /co-teaching field experience models across multiple contexts. In T. Hodges & A. Baum (Eds.) *Handbook of research on field-based teacher education*. Hershey, PA: IGI Global.

RAC members as a whole also made plans for writing the clinical experience RAC section of the proposed MTE-Partnership monograph to AMTE during the 2018 conference.

Consistent with the whole RAC goals, each of the sub-RACS worked on materials that they had already been developing and began thinking about PDSA cycles that they would like to run in the fall to continue improving their products and processes. What follows are brief summaries of the work of each of the sub-RACS since the 2017 MTE-Partnership conference.

Methods Sub-RAC

The Methods sub-RAC finished the multi-year effort to develop the Standards for Mathematical Practice Module #1 last year. It was made available for use across the entire partnership for the 2017–2018 academic year. No updates will be made to this module while multiple individuals of this group are working on writing for publication with respect to the findings. This module focuses on faculty engaging teacher candidates in a quadrilaterals activity, learning to understand what engaging in the standards for mathematical practice as students look like, and capping the experience by asking the teacher candidates to watch a short video with their

cooperating teachers and discuss the standards for mathematical practice. Multiple surveys are included for faculty to collect teacher candidates' work, as well as surveys from their cooperating/mentor teachers.

Lesson Planning Module #2 is a second module that the methods sub-RAC is creating. The sub-RAC has worked through two full years of implementing PDSA cycles on this module. This module team has solicited six pilot sites for Fall 2018 and two for Spring 2019. The module team plans to collect data from the pilot sites, revise the module, and roll it out to the entire partnership for the 2019–2020 academic year. This module focuses specifically on teacher candidates and mentor teachers planning lessons that involve the mathematics teaching practices (NCTM, 2014). They are simultaneously developing a lesson plan rubric that is centered on the Mathematics Classroom Observation Protocol for Practices (MCOP²) (Gleason, Livers, & Zekowski, 2017) and will be used by pre-service teachers and cooperating/mentor teachers to evaluate planned lessons, revised lessons, and implemented lessons.

The third module is the Student Feedback Module #3. The sub-RAC has worked through one full year of development on this module. The module team will implement this module at two sites in Fall 2018, collect and analyze data, and revise the module. Pilot sites will be solicited again for the 2019–2020 year for implementing PDSA cycles. The timeframe for full partnership rollout is planned for the 2020–2021 academic year. This module focuses specifically on the value of providing students high-quality feedback related to mathematical goals as a teaching practice. Components of this module include exploring the different forms of feedback, understanding effective feedback, and structuring high-quality feedback for students.

Co-Planning/Co-Teaching Sub-RAC

Since the 2017 meeting, the co-planning and co-teaching sub-RAC engaged in data collection and analysis activities for the NSF-IUSE grant, facilitated professional development at the University of South Florida, and disseminated components of their work at the Psychology of Mathematics Education-North America Chapter annual meeting, the MAA and AMS Joint Mathematics Meeting, and the Florida Association of Mathematics Teacher Educators. We were also accepted to the Association of American Colleges & Universities (AAC&U) Transforming STEM education meeting later in 2018. The citations for the presentations are as follows:

- Brosnan, P., Cayton, C., Grady, M., Sears, R., & Strutchens, M. (2018, January). *Co-planning and co-teaching with a focus on equity*. Professional development training at the University of South Florida, Tampa, FL.
- Cayton, C., Grady, M., Preston, R. V., Sears, R., Oloff-Lewis, J., & Brosnan, P. (2017, October). *Improving pre-service secondary mathematics clinical experiences through co-planning and co-teaching*. Working group sessions at the International Group for the Psychology of Mathematics Education-North America Chapter, Indianapolis, IN.
- Sears, R. (2018, January). *Using improvement science to promote mathematics teaching practices and equity during clinical experiences*. Presentation at the Florida Distance Learning Association & Florida Association of Mathematics Teacher Educators, Altamonte Springs, FL.
- Sears, R. (2018, November). *Attending to equity in secondary mathematics using co-planning and co-teaching Strategies*. Presentation at the AAC&U Transforming STEM education meeting [accepted], Atlanta, GA.
- Strutchens, M., Sears, R. (2018, January). *Attaining excellence in secondary mathematics clinical experiences with a lens on equity*. Presentation at Mathematics Association of America and American Mathematical Society Joint Mathematics Meeting, San Diego, CA.

At the 2018 meeting, the co-planning and co-teaching sub-RAC identified features and resources that should be available on the website and refined instruments that measure the implementation of co-planning and co-teaching with an attention to equity.

The website for the co-planning and co-teaching sub-RAC will be designed for a practitioner audience. It will include brief vignettes of the various co-planning and co-teaching strategies that promote equity, enacted lessons, sample lesson plans, handouts that can be used to provide an overview of co-planning and co-teaching, and other practical resources that may provide insight for implementation of the model in secondary mathematics classrooms.

The co-planning and co-teaching sub-RAC also refined their just-in-time survey and exit survey so that the sub-RAC can gain insight into how collaborating pairs (mentor teachers and preservice teachers) attend to equity during instruction. Particularly, the collaborating pairs will be asked to explicate what they do to facilitate equitable learning opportunities for students and discuss factors that help or hinder their ability to attend to equity during enacted lessons.

Paired Placement Sub-RAC

Since the 2017 MTE-Partnership conference, members of the paired placement sub-RAC presented at the Georgia Association of Mathematics Teacher Educators (GAMTE) in Eagle Rock, GA, and submitted a paper for the GAMTE conference proceedings. The citation is listed as follows:

Conway, B., Erikson, D., Parish, C., Strutchens, S., & Whitfield, J. (2017, October). *An alternative approach to the traditional internship model*. Paper presented at the Georgia Association of Mathematics Teacher Educators, Eagle Rock, GA. Retrieved from <http://digitalcommons.georgiasouthern.edu/gamte/>.

Additionally, the paired placement sub-RAC members worked on guidelines for orientation sessions and workshops for teacher candidates and mentor teachers, syllabi, and other resources for implementation of the model. They also conducted PDSA cycles and collected data to answer research questions related to the implementation of the model. Members of the paired placement sub-RAC plan to place the implementation materials on Trellis so that other MTE-Partnership teams may access them and implement the model. They will also create questionnaires to go with the materials to determine how well people are able to implement the model with integrity within their context.

References

- Bryk, A. S., Gomez, L. M., Grunow, A., & LeMahieu, P. G. (2015). *Learning to improve: How America's schools can get better at getting better*. Harvard Education Press: Cambridge, MA.
- Common Core State Standards Initiative. (2010). *Common Core State Standards for Mathematics*. Washington, DC: National Governors Association Center for Best Practices and the Council of Chief State School Officers.
- Gleason, J., Livers, S. D., & Zekowski, J. (2017). Mathematics Classroom Observation Protocol for Practices (MCOP²): Validity and reliability. *Investigations in Mathematical Learning*, 9(3), 111–129.
- National Council of Teachers of Mathematics. (2014). *Principles to actions: Ensuring mathematical success for all*. Reston, VA: Author.

Active Learning in Mathematics Research Action Cluster (ALM RAC)

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Co-Leaders

Problem Addressed

While the overall goal of the Mathematics Teacher Education Partnership (MTE-Partnership) is to increase the quality and quantity of mathematics teachers, the Active Learning Mathematics Research Action Cluster (ALM RAC) focuses on freshmen-level mathematics courses: Precalculus through Calculus 2 (P2C2). Student success in P2C2 courses has significant implications for whether students persist in intended STEM majors and careers. Even for those students who do not choose to major in mathematics, science, or engineering, the level of success in entry-level undergraduate mathematics courses such as calculus can drive their decision to persist in postsecondary education.

Nationally, high failure rates in P2C2 courses is the norm. The Characteristics of Successful Programs in College Calculus (Bressoud, Carlson, Mesa, & Rasmussen, 2013) showed the percentage of students with grades of D, F or Withdraw ranged from an average of 25% at Ph.D.-granting universities to an average of 37% at regional comprehensive universities. The ALM RAC members (see Table 1) are committed to improving students' achievement in and dispositions toward mathematics by engaging students more actively in learning mathematics.

The ALM RAC's goals are aligned with the MTE-Partnership's Guiding Principles of Commitments by Institutions of Higher Education through Institutional Focus, Disciplinary Partnerships, and Institutional Support for Faculty. The ALM RAC also addresses the guiding principle of Candidates' Knowledge and Use of Mathematics through future candidates' engagement in Mathematical Practices in introductory-level undergraduate mathematics courses, to deepen their Knowledge of the Discipline. Excellent introductory mathematics courses have the potential to encourage more students to consider becoming secondary mathematics teachers (or at least reduce discouragement among potential future teachers). Additionally, when P2C2 courses utilize learning assistants (undergraduates hired to assist the instructor in facilitating student learning and engagement), this instruction can serve as an early field experience for potential future teachers.

General Approach

The overarching goal is to improve student success with undergraduate mathematics, starting with the P2C2 sequence. This goal of student success is accomplished through effective teaching practices, which are supported by learning environments that are more conducive to student interaction, reasoning, and problem solving and the use of instructional resources to support ALM. Faculty buy-in and institutional leadership supports training for Graduate Teaching Assistant and other P2C2 instructors. Also, for many campuses, undergraduate learning assistants are used to support student work with group activities and enhance student engagement in mathematical activity.

Our working theory of change is articulated in the following diagram:

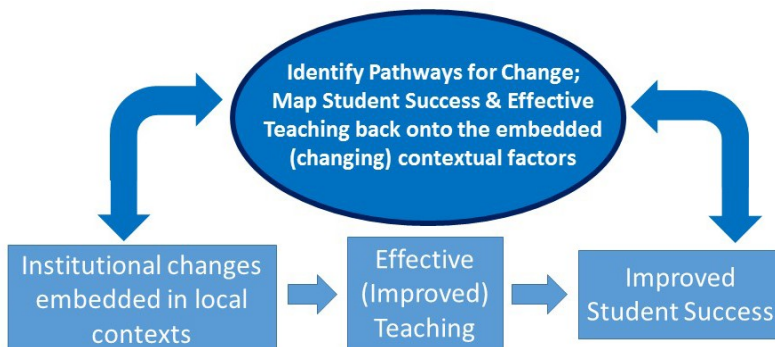


Figure 1. ALM RAC theory of change.

Table 1

Who We Are

Auburn

Ulrich Albrecht, Gary Martin

California Polytechnic Institute Pomona

Laurie Riggs

California State University Fullerton

Alison Marzocchi, David Pagni, Roberto Soto

Colorado State University

Janet Oien

California State University Chico

Christine Herrera

Florida International

Rocio Benabentos, Maria Campitelli, Adam Castillo, Maria Fernandez, Jerry Hower, Laird Kramer, Goeff Potvin, Charity Watson

Fresno State

Lance Burger

Kennesaw State University

Kadian Callahan, Belinda Edwards

Middle Tennessee State University

James Hart

San Diego State University

Janet Bowers, Michael O'Sullivan, Chris Rasmussen, Daniel Reinholz, Matt Voigt

Tuskegee University

Lauretta Garrett, Ana Tameru

University of Colorado Boulder

David Webb*, Robert Tubbs, David Grant
Faan Tone Liu, Eric Stade, Nancy Kress

University of Hawaii Manoa

Monique Chyba, Mijana Jovovic, Sarah Post

University of Nebraska-Lincoln

Wendy Smith*, Allan Donsig, Nathan Wakefield

University of Nebraska at Omaha

Janice Rech, Michael Matthews

University of Northern Arizona

Angie Hodge

University of South Carolina

Sean Yee

Utah State University

Kimberleigh Hadfield

West Virginia University

Vicki Seeley, Nicole Engelke, Matthew Campbell

Western Michigan University

Tabitha Mingus, Melinda Koelling

*RAC co-leaders

Current Progress

Over the past five years, we have worked collaboratively to improve instruction in introductory calculus courses. While the contexts across the 15 campuses are quite different, requiring somewhat different approaches to implementing ALM, we have been able to learn from one another's efforts. We have exchanged and co-developed instructional resources, used common measures to document shifts in student dispositions, and have regularly discussed the local models used to support learning environments that are more conducive to ALM. Several campuses adopted the learning assistant model used by Colorado. Other campuses have been expanding their efforts to include other P2C2 courses, prerequisite courses for Precalculus, and Calculus 3. Discussions across campuses have helped to identify key features of approaches used and have confirmed the critical role of institutional support in promoting ALM. On some campuses, efforts are at a stable place, while in others the efforts are expanding or just getting started. Ongoing work includes more coordinated data collection.

In 2018, we significantly revised our driver diagram, to acknowledge that a focus on equity needs to become more central to the work of our RAC. We added statements about equity to our aim and most of our drivers, to illustrate how such a focus needs to permeate our work. Also in 2018, ALM RAC laid the foundation to build a better knowledge generation and management system to collect and curate resources to support ALM.

A collaborative NSF-funded research grant – Student Engagement in Mathematics through an Institutional Network for Active Learning (SEMINAL) – supports research to better understand how to enact and support institutional change in P2C2 courses. The SEMINAL team is currently analyzing Phase I data and will be publishing a handbook that includes lessons learned from institutions whose cultures include ALM at the P2C2 level.

Opportunities for Engagement

The ALM RAC is currently seeking additional partners who are interested in contributing to future research and products, including the use and revision of instructional resources, professional development materials, strategies to support instructional change, and the use and improvement of measures to study the impact of these changes (full partner). We are increasingly convinced how much contextual features and personal relationships impact the successful implementation and institutionalization of ALM efforts, so we appreciate having diverse partners whose collective experiences can better span the many variations.

We also welcome partners who are interested in field-testing and implementing ALM resources and measures, without the full commitment of contributing to the active learning agenda or development of resources (participating partner).

We note the recent publication by the MAA of an [Instructional Practices Guide](#), has many excellent principles for actively engaging students in learning mathematics. This publication is a great resource for helping to start local conversations about mathematics teaching and learning and has many practical tips for increasing student engagement.

Work of the 2018 Conference

The ALM RAC members who met in Denver spent time thinking through and discussing issues related to leadership, vision, coordination, and data. We recognize the importance of taking time to develop a local vision and goals, and to build intentional plans for accommodating inevitable changes in personnel. Coordination is seen as a key lever that can contribute to more equitable student outcomes as well as help to scale up and sustain ALM efforts. Working with instructor populations with high turnover (e.g., graduate teaching assistants, part time adjuncts) remains a challenge, but coordination has great promise for supporting new instructors.

ALM RAC members present shared their local progress. Some teams have been able to expand ALM efforts out, to include more courses before Calculus, Calculus 3, Business Calculus, Statistics, Discrete Mathematics, and other courses for future mathematics teachers. Other campuses are in the process of turnover of key personnel (chair, coordinator), so are focused on maintaining course improvements. Some campuses are grappling with top-down decisions to end remedial mathematics courses, so are looking to ALM techniques to support and engage all students in P2C2, including those who may have large gaps in their background knowledge. Some campuses are in the early stages of ALM, working on growing the small group of faculty, and focusing on revising P2C2 instructional materials to adopt engaging, group-worthy tasks.

Members discussed data, particularly related to what data a department might collect that can in turn help convince other faculty to try ALM strategies. Western Michigan University is a leader in our RAC related to data usage. Figure 2 illustrates some of the success at Western Michigan and also represents these improvements clearly. The University of Nebraska-Lincoln team shared their success with a course readiness activity that tests students early on over prerequisite knowledge; the activity overall is approximately 95% accurate in correctly predicting which students will pass the course. The activity combines mathematical background with an indication of motivation and ability to seek out resources.

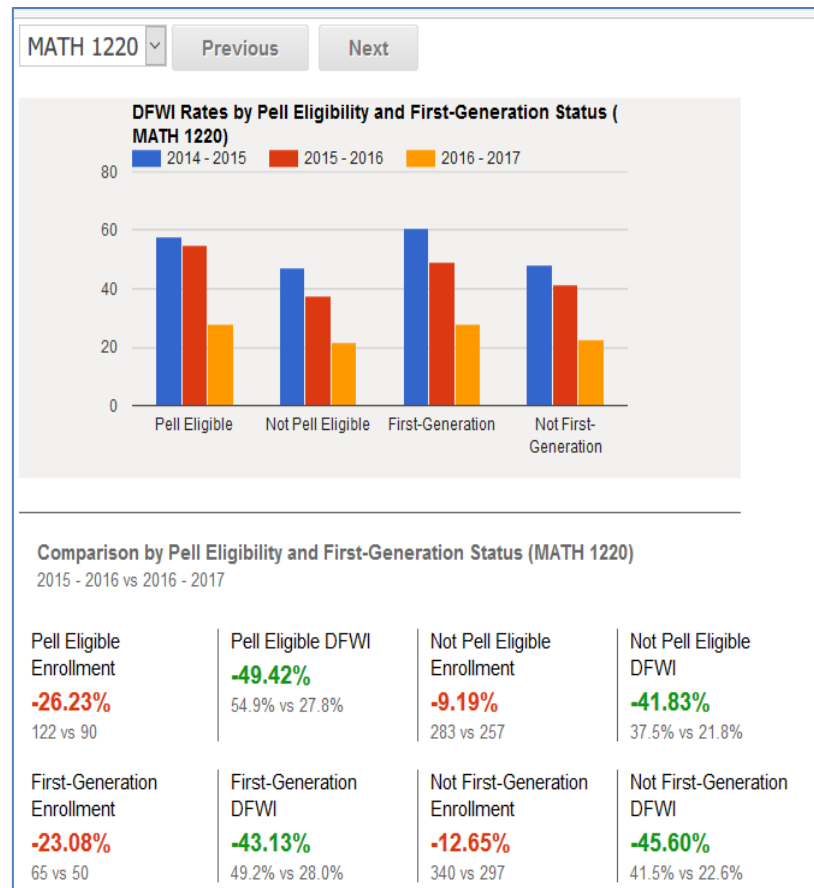


Figure 2. Western Michigan University's student success rates in Calculus 1 since 2014, disaggregated by Pell eligibility and first-generation college student status.

The ALM RAC discussed equity extensively, related to how we might better infuse equity as a central focus of RAC efforts. Building from the five equitable teaching practices (see the report of the Equity Working Group in these proceedings), the ALM RAC members agreed these embody equitable teaching in P2C2 courses. Figure 3 represents the revised driver diagram for ALM RAC, that represents the culmination of our equity discussions.

Active Learning Mathematics Research Action Cluster (ALM RAC) Driver Diagram

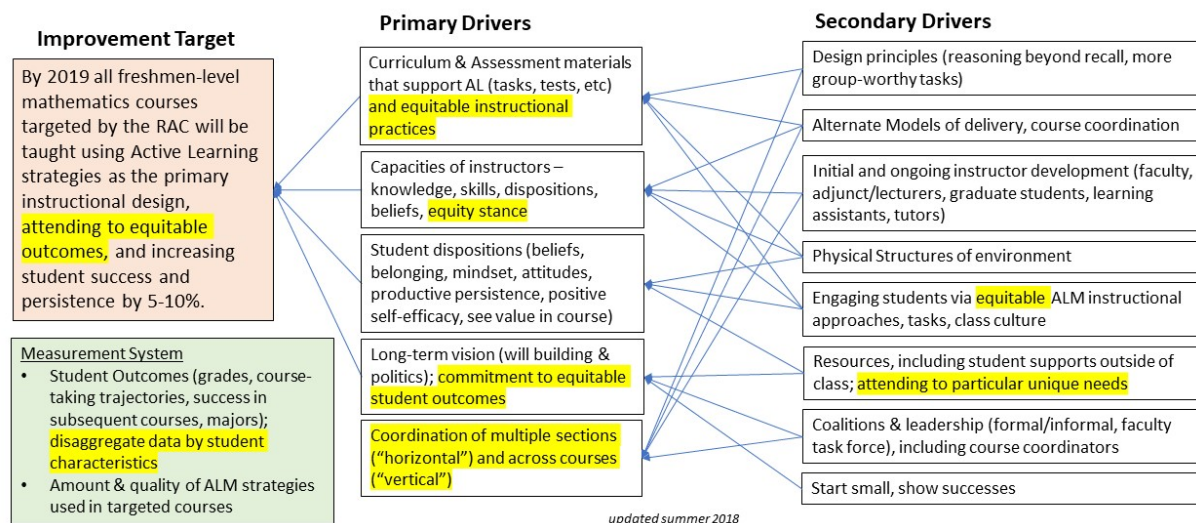


Figure 3. ALM RAC driver diagram, updated in June 2018 to add principles of equity (highlighted in yellow).

For the 2018–2019 school year, the ALM RAC work will include:

- Monthly meetings of the RAC members, to include some predetermined topics as well as time for sharing challenges
- Create an annotated roster of RAC membership that includes particular features of each department (such as learning assistants, graduate student training, supplemental instruction, Calculus 1 activities, etc.)
- Create and curate an online interactive library of ALM resources; such resources will include activities, tasks, assessments, data reports, etc.; we will use a Google Site, and have a Google Form that feeds data into that site.
- Identifying ways to leverage intersections with SEMINAL project resources and emergent findings
- Implementing common data collection and data analyses. Available surveys include Collegiate Active Learning in Calculus Survey (CALCS) to measure student beliefs pre/post across a semester; Post-secondary Instructional Practices Survey (PIPS) to capture instructor beliefs about mathematics teaching and learning; and Student Post-secondary Instructional Practices Survey (SPIPS), a student companion to the PIPS that can correlate student and instructor views. The ALM RAC members also utilize the Math Classroom Observation Protocol for Practices (MCOP²) as a formative tool that is a basis for teaching conversations after observations. The ALM RAC also has some sample interview protocols available for learning from instructors and students.

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The Mathematics of Doing, Understanding, Learning, and Educating for Secondary Schools RAC Report

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Overview and Problem Statement

The Mathematics of Doing, Understanding, Learning, and Educating for Secondary Schools (MODULE(S²)) Research Action Cluster (RAC) is focused on the development of prospective secondary mathematics teachers' (PSMTs') knowledge of mathematics content needed for professional teaching. This focus addresses recommendations set forth in *The Mathematical Education of Teachers II* (MET II; Conference Board of the Mathematical Sciences [CBMS], 2012) for courses in secondary mathematics teacher preparation programs to provide opportunities for prospective teachers to “delve into the mathematics ... while engaging in mathematical practice as described by the CCSS” (p. 46). In addition, this work is aligned with recommendations set forth by the Association of Mathematics Teacher Educators' Standards for Preparing Teachers of Mathematics (2017) to prepare teachers who can use and apply mathematical knowledge for teaching through collaboration among multiple stakeholders (i.e., mathematicians, mathematics educators, and K–12 personnel). The work of the RAC aims to address the identified problem that undergraduate programs fail to lead teacher candidates to: (a) deeply understand the mathematics they will actually teach and (b) experience learning in a manner consistent with what will be expected of them as professional educators (Banilower et al., 2013).

In response to this problem, the MODULE(S²) RAC has established the following objectives:

- Create 12 collaboratively designed modules aimed to develop PSMTs' mathematical knowledge for teaching algebra, geometry, modeling, and statistics in Grades 6–12.
- Pilot and support the implementation of the modules.
- Revise the modules based on implementation data, instructor feedback, and PSMTs' work.
- Evaluate the effectiveness of modules with regards to their ability to develop PSMTs' mathematical knowledge for teaching.
- Disseminate the modules across multiple institutions, beginning with Mathematics Teacher Education Partnership (MTE-Partnership) institutions.

Our theory of change rests on research that demonstrates that use of tasks embedded in pedagogical contexts (Stylianides & Stylianides, 2010) is an important tool for bridging the often-perceived gap between mathematical preparation and teaching practice (Goulding, Hatch, & Rodd, 2003; Zazkis & Leikin, 2010). The cycle of improvement for the MODULE(S²) RAC will be informed by understanding both how the materials are implemented by piloting instructors and how PSMTs engaging with the materials develop knowledge needed for teaching.

Current Progress of the Work

The work of the RAC in 2017–2018 focused on writing of materials, preliminary piloting of modules, and development of tools to assist in the understanding of development of mathematical knowledge needed for teaching. Funded by a five-year collaborative NSF-IUSE grant, Collaborative Research: Mathematics of Doing, Understanding, Learning and Educating for Secondary Schools (NSF Awards #1726707, 1726098, 1726252,

1726723, 1726744, and 1726804), work was driven by the following grant goals:

1. Refine and continue to develop instructional materials in two areas (geometry and statistics) that have been shown in pilot studies to develop PSMTs' Mathematical Knowledge for Teaching (MKT); create materials for two additional areas (algebra and modeling).
2. Create professional development materials and activities to support faculty in carrying out prioritized instructional practices in content courses and in developing PSMTs' MKT.
3. Investigate the conditions of instruction and instructors' use of data that impact PSMTs' MKT, development of MKT, and expectancy and value in using MKT as a resource for teaching.

The RAC members are organized into content area writing teams, a research team, and a professional development team, as shown in Table 1.

Throughout the 2017–2018 academic year, writing teams made significant progress on the writing of modules. Three complete geometry modules, along with sample student assessments, were copy edited and prepared for formal piloting. The first geometry module, *Axiomatic Systems*, also has been revised to reflect feedback from consultant Michael Weiss. The algebra writing team completed initial drafts of all three modules ready for the first round of formal piloting. Revisions will continue throughout the summer of 2018 to incorporate more connections to K–12 curriculum and feedback from the advisory board. The statistics writing team completed drafts of two modules and an outline for the third module. The modeling writing team has developed 16 complete lessons, which are being organized into modules. Common to each complete module are both written and video *simulations of practice* in which PSMTs interact with an excerpt of classroom practice through examination of student thinking and mathematical content. As writing progresses, informal piloting and cross-writing team feedback will be conducted to review for mathematical content, clarity, coherence, and connections to K–12 curriculum.

In addition to contributing to the writing of materials, members of the research team worked in an iterative process throughout the year to develop a framework for analyzing and understanding PSMTs' development of mathematical knowledge needed for teaching. The team cycled between analysis of data gathered in preliminary pilots and review of related literature to develop a framework based in existing literature on the development of MKT (Ader & Carlson, 2018; Rowland, Thwaites, & Jared, 2016; Silverman & Thompson, 2008) and generated through examination of data.

The professional development team also collaborated throughout the year to prepare for the first piloting faculty training, which was held immediately following the June 2018 MTE-Partnership meeting. Plans for piloting faculty training included opportunities for pilots to engage with teaching standards set forth by the Mathematical Association of America and the National Council of Teachers of Mathematics, examine video samples of classroom examples of teacher educator practice in which MODULE(S²) materials were implemented, engage with the materials in mathematical explorations, and rehearse teaching with the materials.

MODULE(S²) RAC members also actively shared their work at conferences throughout the year. Presentations were made at the Joint Math Meetings, the Michigan Association of Mathematics Teacher Educators annual meeting, the Research for Undergraduate Mathematics Education conference, the Tennessee STEM Education Conference, Society of Industrial and Applied Mathematics (SIAM) Education Conference 2018, the International Conference on Teaching Statistics, and the MTE-Partnership meeting Brief Reports. These presentations represent ongoing efforts to share the work in a variety of venues and with various stakeholders (e.g., mathematicians, mathematics educators).

Table 1

MODULE(S²) RAC Members and Institutions and Roles in the Grant

Emina Alibegovic <i>Rowland Hall School</i> Geometry Writing Team	Alyson Lischka <i>Middle Tennessee State University</i> MODULE(S ²) RAC Leader Geometry Writing Team Research Team
Cynthia Anhalt <i>University of Arizona</i> Modeling Writing Team Research Team	Samantha Maddox <i>Jefferson City Schools</i> Statistics Writing Team
Holly Anthony <i>Tennessee Technological University</i> RAC Member	W. Gary Martin <i>Auburn University</i> Advisory Board Member
Jason Aubrey <i>University of Arizona</i> Algebra Writing Team	Margaret Mohr-Schroeder <i>University of Kentucky</i> Advisory Board Member
Stephanie Casey <i>Eastern Michigan University</i> Statistics Writing Team Professional Development Team	Matthew Ondrus <i>Weber State University</i> Advisory Board Member
Ricardo Cortez <i>Tulane University</i> Advisory Board Member Modeling Writing Team	Andrew Ross <i>Eastern Michigan University</i> Statistics Writing Team
Christine Franklin <i>American Statistical Association</i> Advisory Board Member	Jeremy F. Strayer <i>Middle Tennessee State University</i> Grant Lead PI, Research Team Professional Development Team Geometry and Algebra Writing Teams
Brynja Kohler <i>Utah State University</i> Modeling Writing Team Professional Development Team	James Tuttle <i>Washtenaw Technical Middle College</i> Algebra Writing Team
Yvonne Lai <i>University of Nebraska-Lincoln</i> Algebra Writing Team Research Team	Michael Weiss <i>University of Michigan</i> Geometry Writing Team
	John Womack <i>Sky View High School</i> Modeling Writing Team

Accomplishments at the MTE-Partnership 2018 Meeting

At the 2018 MTE-Partnership meeting, the MODULE(S²) RAC's work focused on reaffirming a common vision for the group through revision of the driver diagram and developing a common understanding of the use and structure for simulations of practice in the modules. Through both small-group and whole-group discussion, the RAC arrived at a draft of a new driver diagram that better reflects the current state of our work and goals than the original driver diagram (see Figure 1). Revision of the driver diagram will continue through virtual conversations during Summer 2018. In particular, the group is considering additional secondary drivers that will more clearly delineate the process of dissemination and additional connections between drivers.

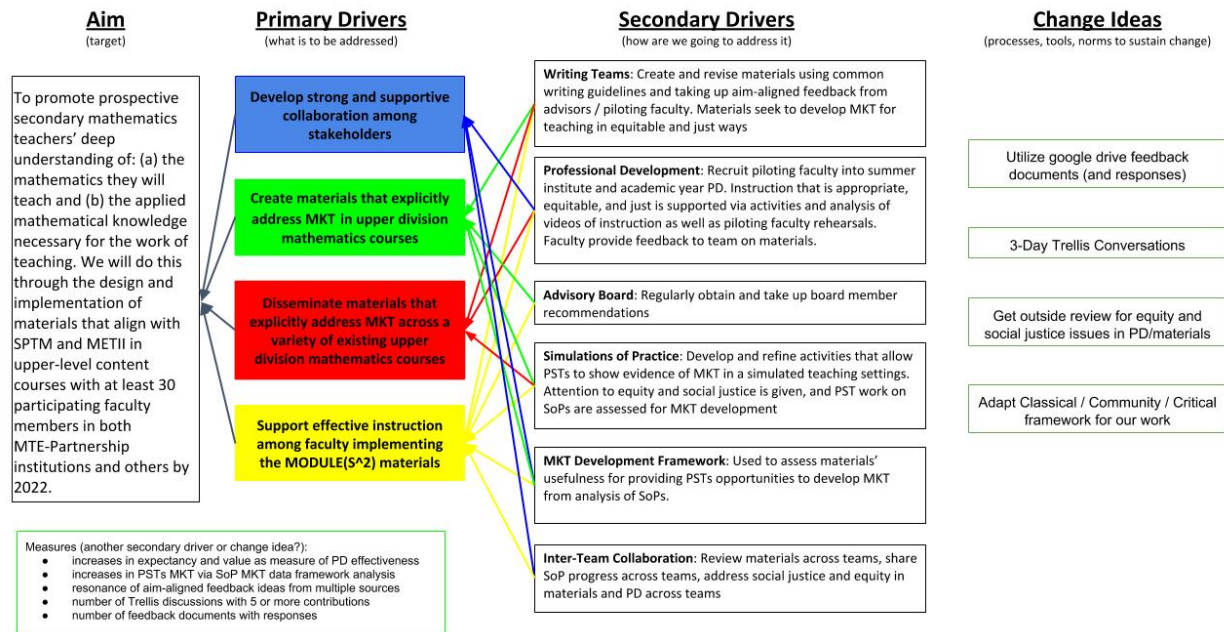


Figure 1. Draft MODULE(S²) revised driver diagram.

RAC members also engaged in examining simulations of practice for three of the content areas (geometry, statistics, and algebra) and PSMTs' sample responses to simulations of practice from the preliminary pilot data in geometry. Through these conversations, agreements concerning format and purpose of the activities were developed. In particular, the RAC recognizes the importance of the incorporation of simulations of practice across a course to provide opportunities for PSMTs to demonstrate and provide evidence of their growing ability to use mathematical knowledge for teaching. Discussions across content area writing teams will continue to examine the uniformity of these activities within the modules.

Moving Forward and Opportunities for Engagement

Immediately following the 2018 MTE-Partnership meeting, the MODULE(S²) RAC hosted nine piloters in the first MODULE(S²) Summer Institute. These nine instructors will be piloting the geometry and algebra materials during the 2018–2019 academic year, which is the first formal piloting year for the project and the first opportunity to gather data on the effectiveness of implementation across a variety of institutions and instructors. Data from both instructors and PSMTs will be gathered and analyzed during this year as the team considers the tandem goals of understanding both how the materials are implemented by piloting instructors and how PSMTs

engaging with the materials develop knowledge needed for teaching.

Moving forward, we seek piloters for modeling and statistics for the 2019–2020 academic year. Participants can be drawn from MTE-Partnership institutions or others. Those interested can indicate so by completing the survey found at <http://tinyurl.com/modules2pilot>.

Finally, the RAC is engaging in discussions concerning social justice and equity and the intersection between research in this field and our development and dissemination of modules for upper-level content courses. There are multiple layers to these issues in our work including (but not limited to): portrayal of equitable teaching practices in both the professional development provided and the written instructional materials; choice of context for mathematical content in problems chosen for the modules; and the ways in which we disseminate the materials. As we move forward with our work, we will continue to grapple with these intersections and strive to make progress in equitable ways.

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Program Recruitment and Retention (PR²) Conference Working Group Report

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The Program Recruitment and Retention (PR²) Research Action Cluster (RAC) convened on June 24 for the first of three working sessions during the MTE-Partnership annual convening. The goal of the RAC was to devise a plan of action to enact a series of Plan-Do-Study-Act (PDSA) cycles based on the driver diagram adopted at the 2017 MTE-Partnership Conference (see Figure 1). Collectively, the group reaffirmed our commitment to understand program recruitment and program retention, and again grappled with the need for attending to issues of diversity, equity, and social justice front and center.

Program Recruitment & Retention RAC Driver Diagram

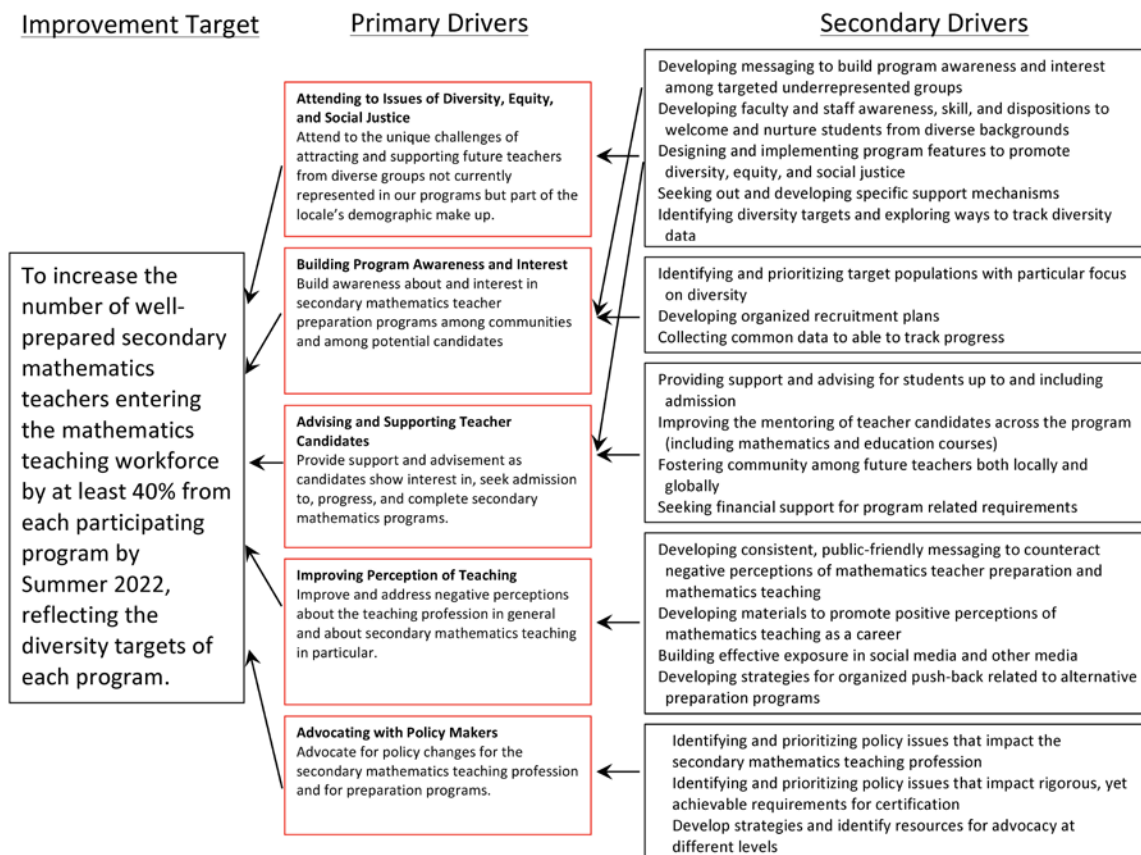


Figure 1. PR² driver diagram.

The RAC members agreed that collecting data regarding what has drawn our students to our programs, and possibly what causes them to leave, needs to be the first PDSA cycle. Therefore, we drafted the Teacher Interest Survey. The survey will be given to students at the beginning of our programs, either in general education courses or methods courses for undergraduate programs or the first course of the credential program for post-baccalaureate and alternate route programs. Each institution may slightly alter the structure of the questions to match the demographics of their program. For instance, race/ethnicity varies largely across the institutions so there may be slight variances in the selection options. Institutional Review Board approval is being investigated to ensure the results may be aggregated and analyzed.

As the RAC worked together, it became apparent there is large variance in the programs. To begin to understand the importance of these variances on recruitment and retention of candidates, general programmatic information was collected. The RAC will use this information to further study the results of the Teacher Survey, specifically looking for trends in similar programs.



Table 1

Present at the MTE-Partnership 2018 Conference

Diane Barrett, University of Hawai'i Hilo	Sally Millsap, Middle Tennessee State University
Dana Franz, Mississippi State University	Jeffrey Pair, California State University Long Beach
Maria Fernandez, Florida International University	Cheryl Roddick, San Jose State University
Seth Jones, Middle Tennessee State University	Jan Smith, Boise State University
Jim McKown, University of Hawai'i Mānoa	Mike Steele, University of Wisconsin – Milwaukee
Julie McNamara, California State University East Bay	(Reactant)

Secondary Teacher Retention and Induction in Diverse Educational Settings (STRIDES)

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Overview of the STRIDES RAC Work to Date

Half of all teachers leave the profession within the first five years, and, unfortunately, this rate is highest for mathematics positions in high poverty schools (Fantilli & McDougall, 2009; Goldring et al., 2014). Furthermore, with half of all current teachers in the United States retiring in the next five years (Foster, 2010), enrollment in teacher preparation programs declining, and teacher turnover costing America \$7.3 billion annually (National Math + Science Initiative, 2013), the mathematics teaching crisis is of major proportion. This crisis leads to many underprepared mathematics teachers and a profound effect on how well-prepared our students are to be successful in high school, college and beyond. Experts agree that addressing the mathematics teaching crisis meaningfully will require building a more cohesive system of teacher preparation, support, and development (Mehta, Theisen-Homer, Braslow, & Lopatin 2015).

The Secondary Teacher Retention & Induction in Diverse Educational Settings (STRIDES) Research Action Cluster (RAC) addresses Mathematics Teacher Education Partnership (MTE-Partnership) Guiding Principle #8: Student Recruitment, Selection, and Support. Teacher preparation programs actively recruit high-quality and diverse teacher candidates and monitor/support them as they complete their programs. Since the inception of MTE-Partnership, the national problem of retaining secondary mathematics teachers within the profession has been a priority. A RAC on retention was proposed at the 2013 MTE-Partnership Annual Conference, but it was not implemented because recruitment was determined to be a higher priority at the time. This decision led to the formation and implementation of the Marketing for Attracting Teacher Hopefuls (MATH) RAC. A few years later, the driver diagram in Figure 1 was created, based on a review of recent literature on retention, with an aim statement and drivers that include support for early career teachers, PLCs, and the need to examine school structures and professional pathways to support/retain teachers.

Members of the RAC decided early on that the work of the RAC must focus on understanding and providing support for both pre-service and early in-service teachers, given the role of a cohesive, continuum of professional learning on teacher growth, and retention. Thus, to launch early initiatives aimed at improving teacher retention rates, STRIDES RAC members designed a survey in Summer 2015 to gather preliminary data on the nature and quality of professional support for pre-service, first-, second-, and third-year teachers. Specific research questions guiding this work were: What is the perceived scope, nature, and impact of professional support for early career mathematics teachers, and how does this (a) change as teachers progress in their teaching career and (b) relate to how likely it is a teacher will remain teaching? Researchers from 13 institutions and secondary mathematics teachers from four school districts designed the pilot survey Reflection on Professional Activities. This survey was created through an iterative design and vetting process, having stemmed from a discussion centered on research-based reasons that teachers leave the field.

Driver Diagram: Secondary Teacher Retention & Induction in Diverse Educational Setting (STRIDES) RAC

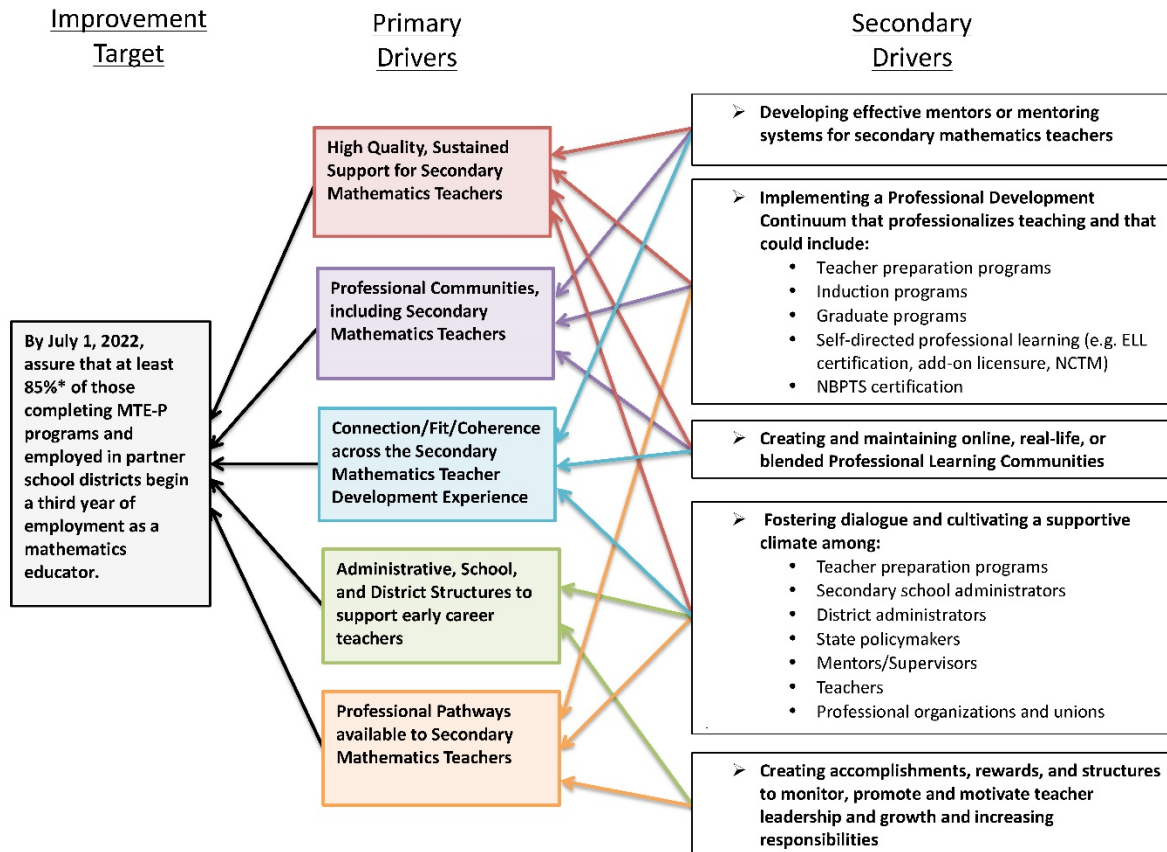


Figure 1. STRIDES driver diagram.

To better understand the degree to which early career mathematics teachers are being supported by professional learning opportunities, professional learning communities, and administrators, the survey allowed participants to specify activities that have helped them grow professionally and the degree to which these activities were worthwhile to them. Also, instructional context (i.e. public, private, etc.) data was collected, as well as whether the early service teachers serve students from special populations (i.e. special education, English-language learner, gifted). Participant estimations regarding the degree that specific professional development activities changed these teachers' practices, as well as the level of "inspiration" these activities invoked, were surveyed, allowing researchers to discern connections between these two measures. Qualitative responses allowed survey participants to provide additional details regarding their support systems. Finally, the degree that the participants feel that their administrators support them professionally was measured, including specific areas (e.g. assessment, instruction, curriculum, classroom management, collegial collaboration, and course assignments/loads). The data from the Summer 2015 pilot survey was analyzed in detail and provided the basis for a revised survey that was sent to MTE-Partnership member institutions in November of 2016 and April of 2017. Data from these two most recent surveys were gathered from participants from a wide geographic area and included responses from 141 early career teachers across the United States (see Figure 2).

The data revealed the extent to which the participants received support in their early careers and what types of assistance were most meaningful for them. An initial analysis of this data was shared at a number of

regional/national conferences, most recently at the 2018 National Council of Teachers of Mathematics (NCTM) Annual Conference in Washington, D.C.

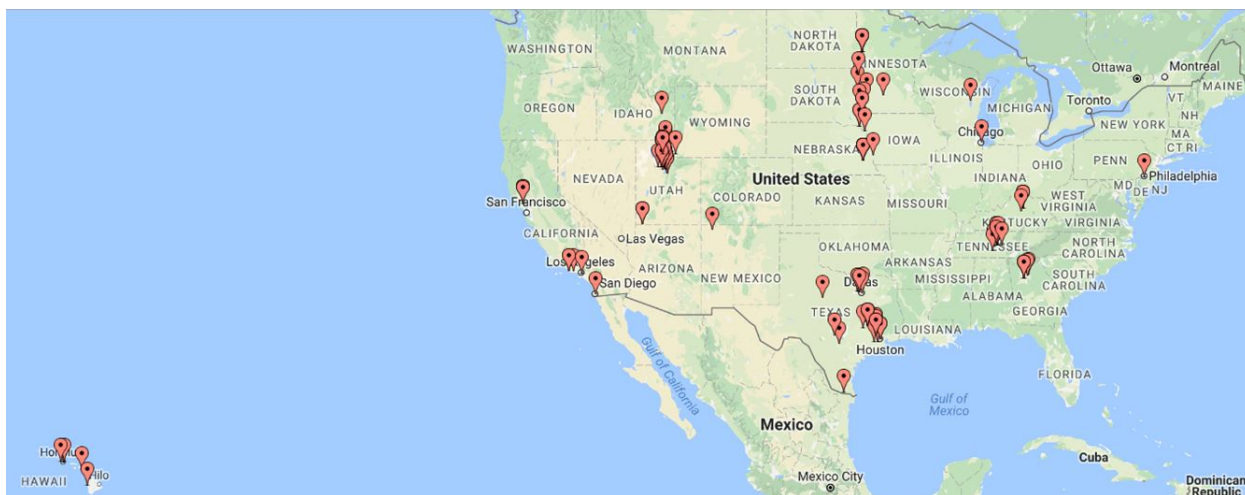


Figure 2. Geographic participation in the STRIDES survey.

Work of the STRIDES RAC at the 2018 Annual Conference

At the 2018 MTE-Partnership Annual Conference in Denver, STRIDES RAC members met for approximately 12 hours of work time. Persons with a variety of backgrounds/skill sets were present (mathematicians, math educators, and school district representatives), a few of who were new to the RAC. Members included (with sub-RAC in parentheses): Laura Wilding (PLC), James Martinez (Administration), Lisa Amick (PLC), Fred Uy (Administration), Judy Kysh (PLC), Travis Weiland (PLC), Lisa Lamb (PLC), and Cathy Williams (Administration); see Figure 3.



Figure 3. STRIDES RAC members at the 2018 MTE-Partnership Annual Conference in Denver.

During the work time, a number of collaborative tasks were performed, facilitated by two of the RAC leaders (Amick and Martinez). The goals for the conference were to: (1) briefly update new RAC members on RAC goals and past efforts, (2) develop specific interventions based on collected data, and (3) investigate relevant grant opportunities to support future efforts. During the first part of the first work session, the group identified

individual and group goals and questions, including: (a) unique needs of math teachers versus non-math teachers, (b) small ways to get interventions started, (c) developing interventions on pilot level, (d) relating ideas generated to our own programs, (e) not getting bogged down on ideas, (f) advantages of starting with funding and then generating interventions based on that profile and vice versa, (g) focusing on specific content, and (h) focusing on specific mathematical practices. During the remainder of the first working session and for the entirety of the second work session, the STRIDES working group engaged in a broad discussion about interventions related to administrative support and PLCs, which correspond to the two subgroups of the RAC. Ideas were charted and included:

PLCs

- Extra observations by a non-evaluative person
- Public service announcement (mentor teachers talking about how they support novice teachers)
- Sending collaborative teams (mentor/early career teacher) to conferences
- Ensuring all early career teachers have a mentor
- Virtual Q&A panel for early career teachers

Administrative Support

- What does “good” administrative support look like?
- Evaluation piece
- Help administrators with their role
- Is evaluation their key point?
- Presentation at administrative conferences
- Administrations giving feedback is key
- Need administrators who build community

Common Spaces

- Intensity, timeliness, frequency, etc., of interventions
- One type of intervention for each year
- Teacher union constraints
- Cultural aspects to consider
- Factors that are out of our hands (e.g., student behavior in these classes)
- Focus on pre-service early career teachers who teach Algebra 1

The group also agreed that it would be more constructive to start with defining substantive interventions and then, if time allowed, look at funding possibilities to support these ideas. Additionally, the group defined a list of best intervention qualities, including: (a) initial design doesn’t have to be “perfect,” (b) achievable with limited resources, (c) easy to upscale to larger areas/participants, (d) easy for participants to see themselves completing, (e) impactful, (f) measurable, (g) pertinent to today’s climate, (h) tied to equity/diversity, and (i) connected to current retention research. On the second and third days, sub-RACs met independently to work on specific intervention ideas with the following goals: (a) define one primary and one alternate, (b) provide an estimate of costs and resources for each intervention idea, and (c) for each intervention idea, define specific tasks, timelines, and persons responsible for implementation. The Administration Support sub-RAC intervention strategy involves the shared viewing by the site principal and early career teacher of five-minute videos focusing on three of NCTM’s eight Effective Mathematics Teaching Practices and includes pre- and post-surveys to gauge personal/ professional connection, learning, and perceived support. The PLC sub-RAC intervention focuses only on teachers in their first year and is multi-faceted. It includes assuring each new teacher has a mentor, having them participate in a virtual

question-and-answer panel, and providing them with a video to watch with their mentor teacher that provides tips on how to strengthen the partnership. Ideas for each sub-RAC were shared with the whole group to gather feedback. Each sub-RAC defined one draft intervention strategy in detail, including timelines for completion of a pilot program in the next four to six months. In addition, the STRIDES Working Group returned to the previously formed goals and best intervention qualities and determined the degree that the draft interventions met these standards. Next, to comply with a request from the MTE-Partnership conference organizers, the working group determined what value our efforts were in connection with other RACs, including the Equity and Transformations RACs. Finally, the group members set upcoming meeting dates to hold one another accountable on the implementation of the interventions, to begin grant writing, and continue collaboration.

Conclusion

The work time allowed for RACs during the 2018 annual meeting was extremely beneficial to STRIDES and allowed researchers to propel the work forward. STRIDES was able to recruit additional members who brought a new perspective to the group, and they, along with veteran members, contributed significantly to the ongoing efforts of the RAC. Work time was efficient and productive, leaving RAC members with a sense of accomplishment and the motivation and goals to continue the work into the upcoming school year. Both sub-RACs developed interventions to test during the 2018–2019 school year and selected grants that could possibly fund further efforts in the future. Interventions will be piloted this year for both sub-RACs, and the research group will continue to meet virtually to share and analyze the data. Both sub-RACs will be working on grant writing in hopes that these small-scale efforts can one day become much larger and have a greater impact on the profession. With the teacher shortage increasing and mentoring programs being cut from states' budgets, the RAC feels that their timely work is of utmost importance and pledges to put a significant focus on this work in the upcoming school year.

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RESEARCH PRESENTATIONS

Implications of a Co-Planning and Co-Teaching Professional Development Training for Pre-Service Teachers and Collaborating Teachers

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Abstract

This study describes pre-service teachers' and collaborating teachers' perspectives of a professional development training, which focused on co-planning and co-teaching in secondary mathematics. Data were garnered from 19 pre-service teachers and 23 collaborating teachers, using a pre-survey, a professional development survey, and personal reflections. The quantitative data were analyzed using descriptive statistics, and the qualitative data were analyzed using a constant comparative analysis. The findings suggest that the professional development helped participants conceptualize how co-planning and co-teaching could be enacted during clinical experiences. We also found that all participants valued collaboration and communication opportunities, hands-on activities, and providing explicit examples for a mathematical context. The collaborative pairs noted they wanted to have more opportunities to engage in co-planning to better enact the co-teaching strategies. The findings of this paper have implications for teacher preparation programs, which seek to prepare pre-service teachers and facilitate professional development training for collaborating teachers and pre-service teachers.

Overview

Professional development can be used to support teachers' professional growth and can vary in duration and pedagogical support (Desimone, 2009). Researchers noted that professional development should attend to content, promote active learning, be coherent, have a stipulated duration, and support collective participation (Garet, Porter, Desimone, Birman, & Yoon, 2001; Desimone, 2009). Regardless of the structure of professional development, researchers should seek to facilitate professional development with consideration to teachers' responsibilities, motivational factors that may impact teachers' engagement with various activities, and research about how teachers learn (Kennedy, 2016). Therefore, in our eight-hour professional development training, we attended to core features identified in the literature (Garet, Porter, Desimone, Birman, & Yoon, 2001; Desimone, 2009) and sought to explicitly address the needs of collaborating teachers who share their space and time with pre-service teachers during clinical experiences.

The overarching research question for this study was as follows: What are collaborating teachers' and pre-service teachers' perspectives of a professional development that focused on co-planning and co-teaching? To answer the research question, we facilitated an eight-hour professional development training at a southeastern university in January 2018. Our professional development training, which focused on co-planning and co-teaching,

was funded by the NSF collaborative grant “Attaining excellence in secondary mathematics clinical experiences with a lens on equity” (NSF- IUSE 17761020). The facilitators of the professional development were members of the Mathematics Teacher Education Partnership (MTE-Partnership) clinical experiences sub-RAC devoted to co-planning and co-teaching. Both collaborating teachers and pre-service teachers attended the professional development and sat in pairs throughout the training. According to Gee and Whale (2016), studies on effectiveness of teachers learning together show that the participants valued collaboration within the community of learners and a “change in practice through a focus on student discourse, student thinking, and questioning strategies” (p. 95).

The goal of the professional development was to illustrate how co-planning and co-teaching strategies may be used to promote equitable learning opportunities during clinical experiences in secondary mathematics classrooms. For our purposes, the concept of equity includes “the fair distribution of material and human resources; intellectually challenging curricula; educational experiences that build on students’ cultures, languages, home experiences, and identities; and pedagogies that prepare students to engage in critical thought and democratic participation in society” (Lipman, 2004, p. 3). Thus, the professional development highlighted how the collaborative pairs can work together to provide opportunities for individualized attention and instructional interventions to meet the needs of each student and established high expectations, thereby promoting equitable opportunities for all students. Hence, to structure the professional development, we provided a 30-minute overview of the importance of equity in mathematics education. We then allocated two hours focused on the Apprenticeship for Learning conceptual framework, which encourages the instructional pair (collaborating teacher and pre-service teacher) to share instructional responsibilities and utilize structured conversations that focus on cultivating students’ learning (Brosnan, Jaede, Brownstein, & Stroot, 2004). This conceptual framework suggests that the pre-service teachers are to be respected as teachers from the onset, even while under the initial guidance of the cooperating teacher. The remaining time actively engaged the audience with the co-planning and co-teaching strategies. The co-teaching strategies discussed were: one teach/ one observe, station teaching, one teach/ one assist, parallel teaching, teaming, and alternative teaching (Friend et al., 2010; Murawski & Spencer, 2011; Sears, et al, 2017). To unpack the various strategies, participants were provided an overview by facilitators and subsequently engaged in activities to reflect the ideas presented. Thus, the participants brainstormed effective instructional strategies, shared their ideas with their instructional pairs, provided feedback on shared lesson plans, participated in structured conversations, and considered how the various strategies may be used for various mathematical topics and for promoting equity. After the professional development, the pre-service teachers were asked to reflect on how to utilize co-planning and co-teaching as part of their instructional practices, within their secondary mathematics methods course.

Methods

The professional development in this study is a component of a larger cross-institutional collaborative research study. We employed a mixed methods research design to gain insights into collaborating teachers and pre-service teachers’ perspectives of a professional development training, which focused on co-planning and co-teaching. The quantitative data were garnered from multiple instruments. In the subsequent paragraphs, we will describe in greater detail the participants, instrument employed, and data analysis techniques utilized.

Participants

The participants in the study were 19 pre-service teachers enrolled in a high school methods course and 23 collaborating teachers within the local school district. The collaborating teachers obtained a stipend of \$100 to attend the professional development, while the pre-service teachers were required to attend the event as a course requirement.

The pairing of the collaborating teachers and pre-service teachers was based on convenience, and the proximity of the schools the collaborating teachers worked at in relation to the pre-service teachers' home addresses. The instructional pair sat together during the professional development training and were encouraged to implement co-teaching strategies during enacted lessons. The collaborating teachers who did not have a pre-service teacher assigned to them worked together and provided additional instructional support to pre-service teachers at their assigned tables.

Instruments

Data were collected via a pre-survey, a professional development survey, and a written personal reflection on the CPCT professional development for a classroom assignment.

Pre-survey. The instructional pairs (pre-service teachers and collaborating teachers) each rated their knowledge about co-planning and co-teaching, strategies to support diverse learners, and assessment strategies employed. They were also asked to provide insights into their knowledge and ability to enact the Common Core State Standards Content Standards (Common Core State Standards Initiative, 2010) and Standards for Mathematical Practice.

Professional Development Survey. At the end of the professional development, participants (pre-service teachers and collaborating teachers) were asked to rate the overall quality of the professional development, the level of participant engagement, and usefulness of information presented. Participants were also asked to share what they liked best about the training, what could be done to improve the training, and additional support needed to implement co-planning and co-teaching strategies.

Reflection on CPCT Professional Development. For the high school methods course requirement, participants were asked to provide a reflective summary of the professional development. Particularly, they had to (1) summarize the goals and objectives of the professional development and (2) provide commentary (with supporting details) of the impact of the goals of the workshop on their teaching and/or pedagogical philosophy.

Data Analysis

We used the Apprenticeship for Learning conceptual framework—in which collaborating teachers initially provide guidance, and over time, pre-service teachers and collaborating teachers share instructional responsibilities—as a lens to analyze the data (Brosnan, Jaede, Brownstein, & Stroot, 2004). Thus, we reflected on how instructional pairs shared responsibilities, the nature of the conversations valued, and their attention to students' learning. The quantitative data collected Likert-scale items on the pre-survey and professional development survey were analyzed using descriptive statistics—namely: frequencies and measures of central tendencies. The qualitative data garnered from the open-ended sections of the pre-survey and the professional development survey and from the pre-service teachers' classroom assignment reflections were analyzed using a constant comparative analysis (Glaser, 1965). We identified emergent themes and reflected on the extent responses varied between pre-service teachers and their collaborating teachers.

Results

The results indicate that the professional development training enhanced the instructional pairs' understanding of various co-planning and co-teaching strategies. To structure the results section, we provide perspectives shared by the collaborating teachers and, subsequently, by the pre-service teachers. We acknowledge that the instructional pairs believed that the professional development was effective in facilitating their learning of the strategies and that co-planning and co-teaching can support student learning.

Collaborating Teachers

The collaborating teachers' perspectives that co-planning and co-teaching strategies can facilitate student learning and foster collaboration between the instructional pairs was shared throughout the training. Moreover, the professional development supported the collaborating teachers' professional learning and highlighted a need for online resources relative to co-teaching and co-planning. The collaborating teachers acknowledge that prior to the training they were most familiar with one teach/ one assist and had some experience with team planning. Very few teachers (5.9%) noted they knew and could implement all of the co-planning and co-teaching strategies before attending the professional development. Nevertheless, as a result of participating in the professional training, the collaborating teachers felt that they gained a better understanding of the co-planning and co-teaching strategies. Evidence for the ways in which collaborating teachers increased their understanding is presented in the sections that follow.

Support student learning. The collaborating teachers noted that co-teaching can support student learning. For instance, the collaborating teachers noted:

[Co-teaching can] increase student engagement and the ability to reach all learners
(Collaborating teacher 1, Pre-survey, January 2018)

Benefits will be watching the students understand and learn from our collaboration. It should be a "tag-team" experience while co-teaching. I may explain it one way where most may understand. However, if there are some students that don't understand, the co-teacher could share his/her method in a way that they all could understand. (Collaborating teacher 2, Pre-survey, January 2018)

Thus, even before the professional development training, the collaborating teachers believed that co-teaching could provide multiple opportunities and alternative strategies for students to gain insight into various mathematical topics.

Professional learning. The professional development helped the collaborating teachers gain insight into co-planning and co-teaching strategies that are supported by research. The collaborating teachers also suggested that they will retain the information shared. For instance, the collaborating teachers noted:

The presentation was a good blend of research and practical application of the co-teach model. (Collaborating teacher 3, Professional Development survey, January 2018)

I liked that there were well-defined strategies for co-planning and co-teaching. These strategies will stick with me. (Collaborating teacher 4, Professional Development Survey, January 2018)

Therefore, integrating research into the training and providing explicit examples of co-planning and co-teaching strategies were valued by participants.

Collaborating teachers valued interaction with pre-service teachers. Moreover, the collaborating teachers valued interacting with pre-service teachers at the professional development because they were able to obtain fresh ideas about various mathematical content. Evidence of this was supported by data obtained from teachers' reflections on the professional development survey. For example, they indicated:

I really enjoyed the interaction between teachers and students. (Collaborating teacher 5, Professional Development survey, January 2018)

The student I was paired with was very bright and it was a real pleasure getting a fresh perspective from him. (Collaborating teacher 6, Professional Development survey, January 2018)

Hence, the collaborating teachers deemed the pre-service teachers' contributions in the professional development to be insightful and were viewed favorably.

Need for resources and open communication channels. The collaborating teachers also noted a need for educational materials relative to the training and an online community that could support their instructional practices and foster communication between the instructional pairs. For example, a teacher wrote:

Links to the PowerPoint or PDF's would be helpful to provide my colleagues. Possibly a contact list or communication board so that pre-service teachers could reach out to mentor [collaborating] teachers if they wish to get some classroom experience before their official internship. (Collaborating teacher 7, Professional Development survey, January 2018).

Hence, in facilitating professional development training, the facilitators should consider utilizing a listserv to disseminate information and strengthen communication between all entities.

Pre-service Teachers

Similar to the collaborating teachers, the pre-service teachers also noted that the professional development was beneficial because it fostered collaboration and could support student learning. The pre-service teacher perceived the use of co-planning and co-teaching fostered professional collaboration and had the potential to increase equitable learning opportunities. The themes that emerged from pre-service teachers' perspectives of the professional development focused on the benefits of collaboration, professional learning, and effective modeling of co-planning and co-teaching strategies. Evidence for the themes in pre-service teacher responses is presented in the sections that follow.

Collaboration. Pre-service teachers found the interaction with collaborating teachers to be beneficial to them. Specifically, they believed that they can gain insight from their collaborating teachers' expertise. The pre-service teachers noted:

What I found most useful from the workshop was simply being able to talk to other teachers about planning, teaching, and students.... This was especially important when we did activities where we would plan mini-lesson plans because the teachers could tell us what their students would struggle with. A lot of lessons we create as students are ideal lessons—and it is hard to address on paper the challenges teachers face when actually implementing a lesson, such as time, student interruptions, and diverse classrooms. This is where observations and collaboration with mentor teachers really helps us (Pre-service teacher 1, Reflection, February 2018)

One of the most useful experiences during this workshop were the conversations with experienced teachers and networking opportunities (Pre-service teacher 2, Reflection, February 2018)

Thus, the pre-service teachers perceived that some of the lesson plans they write for course assignments are written for a utopia, and they are not likely to address the complexities teachers face within a regular classroom setting. Hence, the pre-service teachers believed that the collaboration with their instructional pairs provided an opportunity to gain real-life insights as to what actually occurs in the classroom setting.

Professional learning and enhanced confidence. As a result of participating in the professional development training, pre-service teachers gained insight into how to plan, and the pre-service teachers' confidence in their ability to contribute to the enacted lessons increased. For instance, a pre-service teacher noted:

I think this was a very eye-opening workshop and I hope that it benefited others as much as I feel it benefited me. I think I will be able to lesson plan better (Pre-service teacher 3, reflection, February 2018).

This pre-service teacher's remark indicates that as a result of the training they perceived their ability to plan a lesson was enhanced, and they were enlightened.

Moreover, when co-planning and co-teaching is employed, and the Apprenticeship for Learning conceptual framework is utilized, the pre-service teachers indicated they felt more confident in their ability to enact instruction during their clinical experiences (Brosnan, Jaede, Brownstein, & Stroot, 2014). A pre-service teacher suggested:

The strategies can be useful in learning what works for the students in the class with a teacher that has more experience. It also ensures that I, as an intern, still have an active role in the classroom. Even when observing, I would comment on what strategies work for the students. Though my role will not always be equal to my co-teacher, I think by gradually increasing my role with co-planning and co-teaching, I can learn strategies I would not have learned on my own. Overall, the workshop helped me become more confident of my internship (Pre-service teacher 4, reflection, February 2018).

Therefore, providing a professional development training on co-planning and co-teaching for the instructional pair may contribute to the pre-service teachers developing confidence in their ability to be effective teachers.

Modeling of co-teaching strategies. Additionally, the pre-service teachers appreciated that the presenters modeled the various co-planning and co-teaching strategies as they were being discussed. The presenters' decision to model the concept helped participants realize the strategies were not abstract constructs, rather they were quite practical and could easily be executed well. One pre-service teacher noted:

The workshop included many ways to co-teach and the organizers of the workshop used these techniques while they were teaching us. I was fascinated to see the coordinators using the techniques, but not knowing they were until they told us (Pre-service teacher 4, reflection, February 2018).

Similarly, another pre-service teacher shared the presenter demonstration of the co-teaching strategies facilitated learning and appeared effortless. The pre-service teacher noted:

By far my favorite part of the entire event was when Dr. Cayton and Dr. Grady performed their lecture on co-teaching and I mean it when I say perform. These two women's abilities to effectively teach with all of these co-teaching strategies almost without us even realizing they were using every strategy shows a high level of trust, synergy, and experience that allows them to flow as they do. (Pre-service teacher 4, reflection, February 2018).

Thus, the pre-service teachers acknowledged they valued the presenters' modeling the ideas.

Discussion

The results of this study have implications with regard to professional development for instructional pairs, particularly during clinical experiences. Using the Apprenticeship for Learning conceptual framework (Brosnan, Jaede, Brownstein, & Stroot, 2014) we found that opportunities for student learning can occur when instructional pairs (a) co-plan and co-teach, (b) attend to student thinking and equitable issues, (c) facilitate structured conversations, and (d) are cognizant of contextual factors that can impact teachers' instructional practices. The instructional pairs' perspective of the professional development on co-planning and co-teaching highlights that they valued the collaboration and the modeling of the co-teaching strategies. Moreover, the professional development provided an opportunity for professional learning and an opportunity to reflect on means to support student learning while increasing equitable learning opportunities. Thus, the results of the study suggest that the professional development supported the instructional pairs' learning of how to use co-planning and co-teaching strategies within a secondary mathematics context, promoted active learning, and encouraged collective participation (Garet, Porter, Desimone, Birman, & Yoon, 2001; Desimone, 2009).

Future studies should examine the implication of professional development on the instructional pairs' practices over time. Particularly, careful examination is needed on the nature of the co-planning and subsequent enactment of lessons within the realms of secondary mathematics. This information can enhance the mathematics education literature relevant to co-planning and co-teaching and the implications of professional development on teachers' instructional practices.

Conclusion

In closing, the instructional pairs perceived that a professional development on co-planning and co-teaching to be quite beneficial. The professional development provided an opportunity to collaborate and gain insights regarding means to support student learning and personal learning, as well as provided an opportunity to observe individuals modeling the strategies. Nevertheless, teacher preparation programs need to reflect on when the professional development is offered and a platform that can maintain ongoing communications in order to optimize the benefits of the professional development.

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Building Long-Term Support for Faculty through Graduate Student Instructor Professional Development

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Introduction

Improving university-level instruction is an important step to improving instruction at all levels, and in order to improve university-level instruction, instructors need to master more effective models of instruction and be able to draw on education literature as they continue to develop as instructors. Well-trained, informed instructors are well equipped to be agents of change when they take on faculty positions. However, this mastery requires training and practice.

To train their graduate student instructors (GSIs), many mathematics departments have developed professional development programs. In fact, “effective training of graduate teaching assistants” was identified as one of the seven characteristics of successful calculus programs (Bressoud & Rasmussen, 2015). Several models of professional development are currently used throughout the country (Ellis, 2015). This narrative report will describe one such professional development course at the University of Nebraska-Lincoln. In addition to describing the course, this report follows the methods employed by Miller and Wakefield (2014) to describe some of the potential benefits of the course on participants by allowing them to directly voice their views within the text of this report.

Professional Development

Mathematics GSIs at the University of Nebraska-Lincoln participate in a mandatory professional development program designed to help them develop as teachers. In the first year, GSIs lead tutorial sessions for either Calculus I or Calculus II. In their second year, GSIs serve as instructors of record in either College Algebra or Intermediate Algebra while concurrently taking a one-year course called *Teaching and Learning Mathematics at the Post-Secondary Level* (TLM), which is the focus of this report. To prepare GSIs to be an instructor of record for the first time, GSIs participate in a three-day teaching orientation prior to the start of the second year and the TLM course. The major thrust of the orientation is administrative policies and basics of how the coordinated courses are structured. However, there are also specific breakout sessions devoted to lesson planning, incorporating group work, grading, types of discourse, and issues of equity.

Teaching and Learning Mathematics at the Post-Secondary Level (TLM) is a 3-credit course (2 credits in the fall, 1 in the spring) in which GSIs read mathematics education literature, discuss best-practices, conduct classroom observations, and write about learning and teaching mathematics. In the following subsections, we describe the major components of TLM.

Semester One (2 Credits)

The first semester of professional development aims to introduce GSIs to active learning practices and the literature in support of those practices. The course meets two days a week for an hour each day. The first semester can be broken into four units: *Setting the Stage*, *Our Classrooms*, *Assessment*, and *Our Students*.

Setting the Stage is a unit devoted to introducing GSIs to mathematics education literature and helping them think more deeply about student cognition. Several reading assignments set the stage.

The first reading assignment is *Accounting for Tutorial Teaching Assistants' Buy-In to Reform Instruction* (Goertzen, Scherr, & Elby, 2009). In their paper, Goertzen, Scherr, and Elby argue that the level to which a graduate student buys into reform instruction has a significant impact on the fidelity of implementation. In TLM, this paper serves to show GSIs how their attitude toward the active learning instructional model at Nebraska can carry into the classroom and affect the efficacy of the model. The discussion of this article concludes by asking GSIs to reflect on the question "What steps could an instructor take to ensure that their own attitudes about teaching and mathematics do not negatively impact their students learning?"

After having established the importance of buy-in, graduate students are introduced to their first model or theory of learning. *APOS: A Constructivist Theory of Learning in Undergraduate Mathematics Education Research* (Dubinsky & McDonald, 2001) provides GSIs with an explicit, accessible model that they can immediately apply to their own students. The APOS model also helps GSIs become familiar with new vocabulary, which they can use in their discussions of student learning. Most graduate students find APOS to be an interesting theory and a valuable way of thinking about their students.

GSIs are also introduced to Constructivism in order to further deepen their knowledge of student learning. In their essay *Constructivism*, Tsay and Hauk (2013) introduce the concept of constructivism and, in particular, the language of accommodation and assimilation using examples from college level introductory mathematics. This essay gives GSIs the opportunity to think more deeply about their students and see the importance of having their students construct knowledge for themselves.

Setting the Stage culminates with students writing a three- to five-page paper in response to the prompt: *Detail your own view of how learning occurs, how it applies to your classroom, and how it compares with constructivism. You do not have to agree with constructivism, but you do need to demonstrate that you have a working understanding of constructivism. At a minimum your paper should address issues such as: How do students in your class learn? How can you evaluate when a student has learned a topic? In your view of learning, what can you do to improve student learning? If a constructivist visited your class, how would they say that learning was occurring?*

Our Classroom is the second part of TLM. In this part of the course students begin to think about the mathematics content, active learning, and the classroom environment. Several readings are used to spark discussion.

In *Leaves and Caterpillars: The Case of David Crane*, Smith and Stein (2011) argue that carefully selecting and sequencing when and what students present to their peers is a central component of mathematical discussion. After reading Smith and Stein's narrative from an elementary classroom, GSIs are given the opportunity to look at samples of student work from Intermediate Algebra and discuss how they would select and sequence student presentations.

A major component of the mathematics content taught in both Intermediate and College Algebra at Nebraska involves solving applied problems, and in many cases, students are asked to solve these problems before

being formally “taught” the standard computations. *Mathematics in the Streets and in Schools* (Carraher, Carraher, & Schliemann, 2004) provides GSIs with evidence that the traditional method of teaching a standard algorithm and then applying that algorithm to a specific context may not be the best method for every student.

One of the most difficult topics that GSIs encounter as novice precalculus instructors is transformations of functions. Many undergraduate students struggle to understand transformations of functions in ways that most graduate students have not experienced. Reading Lage and Gaisman’s (2006) article *An Analysis of Students’ Ideas About Transformations of Functions* helps GSIs to recognize some of those struggles and allows the class to have meaningful discussions about a specific topic that is difficult for many instructors to teach effectively.

At this point in the semester, GSIs have been exposed to enough mathematics education research and student work that they are ready to tackle the first major project. For this assignment, GSIs are asked to collect and analyze some work from students in the courses that they are teaching, write up an analysis of some of the student difficulties, and develop a plan for helping students to overcome these difficulties¹.

In *Assessment*, GSIs are introduced to formative and summative assessment of both their students and their teaching. This section aims to foster a realization that effective teaching requires us to assess both our own teaching and our students’ learning. The first major topic included in this section is course evaluations.

In *Teaching Assistants and Mid-Term Feedback from Students*, Yestness, Hauk, and Nasir (2013) address issues such as: how to improve the quality of feedback received by undergraduates on midterm evaluations, how to filter what students say when providing feedback to the instructor, and how to respond to the feedback received by students. This paper is also paired with the associated video case study from <http://collegemathvideocases.org> and provides GSIs with the opportunity to interpret and use mid-semester feedback in a meaningful way.

In his classic article, *Benny’s Conception of Rules and Answers in IPI Mathematics*, Erlwanger (1973) brilliantly demonstrates both the dangers inherent in using summative assessment as the only means to assess student learning and the value of using qualitative data to explore student conceptions. GSIs are encouraged to critically evaluate their own assessment methods and look for ways to gain a deeper understanding of their students’ conceptions.

The final component of the first semester is a section referred to as *Our Students*, which consists of an extended discussion of the people in the classroom, their needs, and how we can most effectively teach these individuals. For many GSIs, learning mathematics has always come easily and the idea of struggling with mathematics is foreign. Thus, the primary goal of this section is to help GSIs develop empathy for their students.

Mathematical Autobiography Among College Learners in the United States (Hauk, 2005) tells the mathematical story of several students. GSIs are faced with stories of students who have developed strong emotions towards mathematics. These stories help GSIs to understand that the events playing out in their classrooms may not be the result of laziness, lack of motivation, or a desire to cheat the system but rather the result of a previous experience with mathematics. Many GSIs comment that this is the most moving section of the course and has a big impact on them as mathematics instructors.

¹ For further information on this assignment and analysis of this assignment we refer the readers to (Lai, et al., 2016) and (Miller, Wakefield, & Lai, 2018).

Semester Two (1 Credit)

The second semester of TLM focuses on describing student learning, and the class meets once a week. GSIs look at definitions of some terms from a particular learning theory and then proceed to discuss how those terms can be used to describe events that are taking place in the classes that they are teaching. This semester varies from year to year in exactly what is covered, but at a minimum each of the following learning theories are discussed for at least one day, and often two: Behaviorism, Social Cognitive Theory, Information Processing, Situated Cognition, Radical Constructivism, and Social Constructivism.

The goal in the second semester is to provide GSIs with the vocabulary to describe and make sense of how students are learning in their classrooms. GSIs also observe one another teach and write an essay on their observations during this semester.

Together the first and second semester make up the 3-credit professional development course. There is much more that can be said about the course. However, it is also worth discussing how TLM impacts graduate students. To this end, two of the authors, who were graduate students in the course in different years, will discuss their experiences in the course, how they initially viewed the components of the course, and how those components impact their teaching today.

Personal Narratives

Prior to attending graduate school at the University of Nebraska-Lincoln, neither one of us had taught mathematics in a formal setting, taken a pedagogy course, or experienced active learning as a student. The TLM course helped both of us think about learning and teaching in a deeper way as we taught our own class for the first time. Below we describe our combined reflections on the components of the TLM course and how it affected us as teachers².

*Having a formal introduction to pedagogy was a crucial component to my evolution as a teacher. I remember being willing, but skeptical, of the reformed Precalculus courses and their focus on active learning. I had a full year of leading Calculus recitations, my students' exams scores were higher than average, and I had good evaluations. I felt as though the reformation and our pedagogy course may have been more helpful to my peers than myself. After reading Goertzen, Scherr, and Elby (2009), I had a shift in perspective about student learning and was motivated to buy-in to the goals of TLM for the benefit of my students. In conjunction with an introduction to constructivism and its role in cognitive development, I began to view learning from the perspective of the learner. I was more interested in my students' organization of mental schemes and thought processes through problem solving, rather than how I might present the material as a good speaker and lecturer.

**Our Classroom* helped me to implement active learning in my own classroom. In particular, Carraher, Carraher, and Schliemann (2004) was eye opening. Brazilian children, with little formal schooling, could demonstrate arithmetic proficiency while selling fruit in a local market despite the absence of abstract mathematical training. Their abilities strongly emphasized the importance of teaching mathematics within the setting of real-world applications and the value of students' personal interpretations of an abstract problem. This concept uniquely prepared me to teach several semesters of mathematics for pre-service primary school teachers, where the students would face the interpretive nature of their own students in the future. The students had weekly assignments that involved reasoning through classical problems like Euler's Seven Bridges of Königsberg. By encouraging original thought and productive failures, I was able to support the learning of interesting mathematics

² Hamidi and Uhing took turns writing the following paragraphs. An * indicates Hamidi's narrative and ** indicates Uhing's narrative.

and give future teachers several personal experiences that they can draw upon when working with their own students.

****Assessment** helped me think about how to evaluate my teaching and different ways of assessing student learning. Shortly after reading Yestness, Hauk, and Nasir (2013), Dr. Wakefield recommended that we administer mid-semester teaching assessments and gather feedback from our students about our classes. After comparing our standard departmental mid-semester assessment form with the one used by Yestness and her colleagues, I decided to modify our departmental survey to incorporate more student-centered questions. My goal in doing this was to help students reflect upon their own progress in the class as well as gather feedback on what areas of instruction I could improve upon. I have continued to use and modify this mid-semester feedback survey to help assess and improve aspects of my teaching in the courses that I teach³.

****The next paper we read as part of Assessment** was about Benny (Erlwanger, 1973). I remember being shocked by this paper and would categorize this as one of my most memorable experiences from TLM. Reading about Benny helped me recognize the importance of formative assessment and reiterated the need for me to talk with my students and try to understand what they are thinking. It also highlighted an advantage of using active learning methods and allowing students the opportunity to work on problems in class since I am able to walk around, look at what students are doing, and ask them questions about what they are thinking.

****During the last component of the first semester, we talked about our students.** I was not surprised by the stories detailed in Hauk (2005) as I was aware of the potential for students to have pre-existing feelings about mathematics from their previous experiences. However, our conversations about this topic did reinforce the importance of considering students as individuals and trying to understand their perspectives and feelings about mathematics.

****The main emphasis of the second semester was exploring different learning theories.** Reading and learning about these theories made me aware of the breadth of research that has been conducted in this area. It also helped me become more familiar with specific terminology and vocabulary that I could use to talk about learning and teaching mathematics.

****Another activity that we did as part of TLM was conduct classroom observations of both faculty members and peers.** This experience allowed me to view teaching from an “objective” outside perspective and helped me to reflect upon my own teaching methods. Up until that point, I had never sat in on a class solely to observe the teaching and learning that were taking place in the classroom. Instead of focusing on the course content, I was able to think about the teaching decisions that were being made and how those affected students in the class.

TLM helped us think about how our experiences as learners should impact our teaching. Both of us came into TLM caring about teaching and thinking that we were good teachers, but TLM helped us to realize that we still had a lot to learn about pedagogy. Participating in TLM has concretely helped us to become better teachers in several ways. As a result of taking this class, we are able to interpret and evaluate how math education literature applies to our own teaching and learning. Furthermore, we have a rich teaching support network because our peers have also participated in TLM, and we have a common framework and vocabulary with which to discuss our shared teaching experiences. The knowledge we developed and the experiences we gained from TLM will continue to impact us in our careers as we teach future generations of mathematics students.

³ Comment from Wakefield: In fact, the entire first year program and many others in the department are now using Uhing’s modified version of the Mid-Semester Assessment Form.

Conclusions and Implications

The narratives in this reflection demonstrate that mathematics Ph.D. students are capable of both reading and applying mathematics education research and growing as educators through a course that utilizes research papers to drive discussion of their own classrooms. At the University of Nebraska-Lincoln, graduate students are given a single course release to allow them to participate in the course. For many institutions, course releases require a significant investment of resources. However, the Nebraska mathematics department has been pleased with the results and continues to invest in GSI professional development. Ultimately, the goal of this professional development is increased student learning, not just in the immediate future, but over the course of each graduate student's lifelong career. In these two specific cases, TLM has accomplished this goal, and we believe these two cases generalize to other graduate student instructors who have also gone through the TLM course.

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Programmatic Effects of Capstone Math Content and Math Methods Courses on Teacher Licensure Exams

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Abstract

This chapter reports on how well coursework, design, and implementation of our secondary mathematics programmatic changes have influenced teacher candidate performances on teacher licensure exams (Praxis II, edTPA: educative teaching portfolio assessment). Our goal is to provide empirical evidence for the Mathematics Teacher Education Partnership (MTE-Partnership) to leverage institutional change where institutional commitment to programmatic investments of coursework and faculty load may be difficult. The data used for analysis consists of all program completers in the last four graduating cohorts (2014–2017) and their associated data collected as part of our Council for the Accreditation of Educator Preparation (CAEP) National Council of Teachers of Mathematics (NCTM) Specialize Professional Association (SPA) accreditation review. Our findings highly suggest that well-designed, rigorous capstone mathematics courses and sequenced mathematics methods courses focusing on developmental trajectories for instruction have a large effect size on licensure exams. This research intersects the work of the Research Action Clusters; MODULE(S²) and Clinical Experiences, as well as the Program Transformation working group.

Keywords: Praxis II Exam, edTPA, capstone math courses, math methods courses, clinical experiences

Introduction

In the past 10 years, the critical shortage of certified middle and high school mathematics teachers has grown more critical (U.S. Department of Education, 2016). One factor associated with this increase in the critical shortage has been the high-stakes testing environment derived since No Child Left Behind (NCLB) in the early 2000s. While K–12 schools have been heavily influenced by NCLB testing requirements, high-stakes testing has moved rapidly into teacher preparation programs as a result of the NCLB requirement of producing *highly qualified* teachers. State departments of education were quick to adopt specific testing measures external to universities and colleges to warrant the highly qualified status.

Since early 2012, the Association of Public Land-grant University's (APLU) MTE-Partnership has been using a Networked Improvement Community (NIC) model to develop a framework of guiding principles for preparing teachers of mathematics. In 2013, a set of Research Action Clusters (RACs) were organized to carry forward research projects designed to solve particular problems in secondary mathematics teacher preparation. The use of the NIC model (Bryk, Gomez, & Grunow, 2011) has a very specific purpose for the MTE-Partnership. That is, the RACs focus on solving problems by joining academic research, clinical practice, and faculty expertise to create a profound shift in knowledge for both researchers and practitioners that finds solutions to distinguish best paths (plural assumption) for developing well-prepared, highly knowledgeable beginning teachers of mathematics.

Problem and Purpose of Study

Given the increasing shortage of certified mathematics teachers and high stakes licensure exams for teacher candidates (TCs) in higher education programs, mathematics teacher preparation programs need to know if investments in new or modified courses, additional faculty, and hours of observation are investments that will pay off with TCs well-prepared to pass high stakes licensure examinations. That is, these examinations should essentially be formalities without reducing the number of well-prepared mathematics teachers that higher education institutions develop. Keeping attrition low in programs is a goal, but not at the expense of watering down the preparation to *teaching to the test*. Rather, we focus more on the development of positive beliefs and dispositions, mathematical knowledge for teaching, and pedagogical skills that provide foundational learned knowledge to succeed on licensure exams without a test-prep mentality.

Our purpose is to provide the outcomes of a near-fully transformed programmatic design that aligns to the Conference Board of the Mathematical Sciences (CBMS) and the Association of Mathematics Teacher Educators (AMTE) recommendations while keeping the MTE-Partnership Guiding Principles as foundational to all programmatic changes. By providing our programmatic outcomes on licensure exams as they related to two capstone mathematics courses and a sequence of three mathematics methods course semesters with clinical experiences, we provide programmatic effects on these licensure exams.

Conceptual Design of Program

The design of our program consists of a two-year cohorted model in upper division courses. Prior to the start of their junior year, TCs must have completed the calculus sequence, an introductory business statistics course, an intro to education 1-hour seminar, and discrete mathematics where proof techniques are learned. Linear algebra is a co-requisite with the first capstone *advanced perspective* course though prior experience and data shows higher levels of success if linear algebra is finished before the first capstone course. We define capstone mathematics courses as those that examine the secondary (Grades 6–12) mathematics from an advanced perspective.

Mathematics Capstone Courses

During the penultimate year in the program, the TCs enroll in a two-semester sequence of mathematics courses designed around the recommendations of *The Mathematical Education of Teachers I and II* reports (CBMS, 2001, 2012). These courses focus on connections across different branches of mathematics, grade-level standards, and expectations. The first semester primarily focuses on polynomial and rational functions and their connections to integers and rational numbers, rings and integral domains, short-term and long-term graphical behavior of functions, and unique prime factorizations. The second course centers on studying geometric transformations through synthetic geometry, functions of the complex plane, linear algebra and vectors, and multivariable functions with two-independent and two-dependent variables. The course additionally explores group theory through the study of the group of transformations, families of functions via connections with transformations of the plane, and calculus optimization problems focusing on geometric properties.

The classroom culture in these capstone courses involves a mixture of student exploration, whole-class and small-group discussions, proof of mathematical theorems, applications of mathematical ideas, and some lectures. Appropriate uses of technology such as graphing calculators, GeoGebra, and spreadsheets are used throughout the courses for exploration, modeling, and mathematical justification.

Embedded within these two mathematics capstone courses, TCs complete web-based learning modules from Assessment and Learning in Knowledge Spaces (ALEKS). This tool allows TCs to practice procedural skills and

to review or learn the secondary content standards while honing their conceptual understanding within the capstone courses. The assessments for the web-based learning module reflect the content standards for secondary mathematics students. TCs are required to master 95% of the content to pass the course. They spend on average 30 hours mastering the required content for the first capstone course and 17 hours for the second capstone course.

Author #2 had the unique opportunity of participating in the capstone sequence as a graduate student. In his observation, ALEKS reinforces mathematical skills for TCs and fills their knowledge gaps from the 6–12 curriculum. This is necessary for preparing TCs not only to succeed on the teacher licensure exam but also to relearn necessary skills for teaching 6–12 mathematics.

Mathematics Methods Courses

Over the course of three semesters before the full-time student teaching semester, TCs complete five courses specific to their preparation for the student teaching internship. In semester one, a STEM-focused introduction to secondary education integrates math and science TCs to explore issues of equity, diversity, collaboration, and professional practice. Alongside this course in semester one, TCs complete a math methods course focused specifically on the use of different technologies for enhancing mathematics teaching and learning. By the end of semester one, basic lesson planning ability is assessed.

In semester two, a second math methods course focuses specifically on the 6–12 curriculum standards and resources and mathematical tasks embedded in lesson planning. A final hallmark lesson plan is submitted at the conclusion of the semester. We use an advanced rubric for this hallmark lesson plan as one of the major assessments for our NCTM SPA review.

In semester three, two specific courses are completed in addition to generalist coursework. First, a math methods course focuses on unit planning (8-10 days of instruction) and includes an assessment of the unit plan using a rigorous rubric that is one of the NCTM SPA assessments. Next, a clinical experience course focuses on the reflective nature to improve based on the evaluation of lessons implemented in the schools. This course includes: (1) a two-week seminar to start the semester that includes the MTE-Partnership Clinical Experience Methods sub-RAC Mathematical Practices Module, (2) three formal observations of teaching in the schools with the Mathematics Classroom Observation Protocol for Practices (MCOP²; Gleason, Livers, & Zelkowski, 2017), (3) scored lesson plans based on the enactment and questioning, and (4) attending the state Alabama Council of Teachers of Mathematics annual fall forum. The standards set forth on the hallmark lesson plan rubric, unit plan rubric, MCOP², and final course grades determine if the standards have been met to move into the internship. We encourage readers to refer to the MTE-Partnership proceedings paper for our scoring criteria with the MCOP² (Zelkowski & Gleason, 2016).

Methodology

We examined the full cohorts to have completed the restructured, transformed sequencing of coursework in preparation for the student teaching internship. Because our programmatic changes were implemented in 2012, we analyzed the cohorts who graduated in 2014 through 2017 resulting in a total of N=52 TCs who all completed the same assignments and coursework and were scored on all our NCTM SPA rubrics and the MCOP². Also of note, the 2014 cohort was the first to be required to pass the new Praxis II exam #5161, as well as complete our programs' predecessor to edTPA, the Teacher Work Sample (TWS). In cases where any TCs used a grandfathered score on the Praxis II #5061 or #0061 due to summer testing after the capstone sequence (August 1, 2013, was the state's cut off date for the 2014 graduating cohort), we used the national scoring results to convert linearly to the new exam. We used the quartile published points from 2012-13 on the old test and 2013-14 on the

new test to determine a linear model for conversion. Ten rubrics were used in the TWS as opposed to the 15 of edTPA. A simple linear conversion with a scale of 1.5 was used for the conversion from TWS to edTPA. We also used TCs from the 2016 and 2017 cohorts who elected to complete edTPA as a pilot group before edTPA was required in lieu of TWS. These scores validated our linear conversion model and verified the conversion had a high correlation ($>.90$).

We constructed two models for analyses using multiple regression. In the first model, we considered all final grades in mathematics courses in the mathematics major with adjustments to transferred course grades based on known historical grades earned in the next course (e.g. one grade less in calculus transferred from community colleges). We did not adjust for AP scores since we only had Pass records (not whether TCs earned a score of 3, 4, or 5). We included ALEKS assessments (NCTM SPA assessment) used in both capstone mathematics courses (pre-test, post-test, time spent in ALEKS), as well as a technology content knowledge midterm and final exam in the technology math methods course (assessments of math ability standards). We further considered other overall measures such as the teaching field grade-point average (GPA) and overall GPA earned at UA. We did not consider all credits earned as history has shown transferred coursework from community colleges inflates GPAs, hence the adjustments made. All these measures constituted considerations of our independent variables. Praxis II #5161 was our dependent variable (includes converted #5061, #1061 scores) in the first model. In the second model, we considered all final grades in the five mathematics education courses, the hallmark and unit plan assignment rubrics (NCTM SPA assessments), MCOP² factor scores and total score averages on the three observations, the total number of clinical hours before internship, and overall GPA. The edTPA was our dependent variable (includes converted TWS scores).

Results

Our regression models are reported in Tables 1 and 2 using the stepwise procedure to report the most significant to least significant independent variables. We discuss the results following the respective tables.

Table 1

Summary of Multiple Regression Analysis for Significant Variables on Praxis II (N=52)

Variable	Praxis II Test Score Model				
	<i>B</i>	<i>SE B</i>	β	<i>t</i>	Sig.
(Constant)	111.386	15.856		7.025	0.000
Capstone 1 – Adv. Alg. Connections.	7.868	2.185	0.369	3.600	0.001
ALEKS Capstone 2 Time (hours)	-0.621	0.180	-0.335	-3.453	0.001
Capstone 2 - Geometry	4.460	1.799	0.234	2.480	0.017
Tech Content Knowledge Midterm	0.354	0.172	0.180	2.056	0.046

Note: The adjusted $R^2=0.683$ with a Praxis II mean score of 167.32. Means of the independent variables listed respectively were 3.034, 17.335, 3.067, and 82.356. VIF of all independent variables < 1.63 . Durbin-Watson=2.180. Regression assumptions met.

First, we recognize the significant constant in the model. Praxis II is scored on a 100-200 score and the constant indicates an expected score of about 111 prior to the experiences during the junior year in the two capstone mathematics courses and the first mathematics methods course on technology. Prior ability and coursework such as the calculus sequence completed in the freshman and sophomore years explains the significance of the constant. We would expect 100% of our TCs to fail the Praxis #5161 exam without the junior year experience. Second, we see that for every letter grade (e.g., 3.33=B+, 1.67=C-) on a four-point scale with +/-

considered, the first capstone course grade adds nearly 8 points to the Praxis score and about 4.5 points for the second capstone course. Third, we see that if TCs spend an above average time (>17 hours) working on ALEKS in the second capstone course, they generally would lower their Praxis II score. This means, if it takes 30, 40, or more hours to reach proficiency on basic skills and knowledge on high school geometry and trigonometry, they are very likely to have a lower Praxis score (e.g., 40 hours means losing nearly 25 points on Praxis). Lastly, we see that the midterm technology content exam score (0-100) contributes significantly. Scores range from mid-50s to upper-90s generally, with most TCs scoring in the 75-93 range. A difference of 20 points from the mean indicates about 7 points on the Praxis II.

Overall, we interpret these data to imply a heavy and large effect on Praxis II scores based on the junior year capstone courses, ALEKS, and the content heavy first math methods course on technology. The regression model explains nearly 70% of the Praxis variance in scores. Using the population means, we see a positive contribution of nearly 24 points from the first capstone course, nearly 14 points from the second capstone course, and nearly 30 points from the midterm in the math methods tech course. Lastly, the average time to reach geometry/trig proficiency in ALEKS deducts nearly 11 points.

Table 2

Summary of Multiple Regression Analysis for Significant Variables on edTPA (N=50[^])

Variable	edTPA Total Score Model				
	<i>B</i>	<i>SE B</i>	β	<i>t</i>	Sig.
(Constant)	6.383	4.513		1.414	0.164
Unit Plan SPA Rubric 3C	1.813	0.615	0.313	2.949	0.005
Hallmark Lesson Plan SPA Rubric 2B	1.741	0.515	0.339	3.383	0.001
Clinical Experience Course	2.783	1.008	0.283	2.762	0.008
Hallmark Lesson Plan SPA Rubric 3C	1.027	0.451	0.216	2.279	0.027

Note: The adjusted $R^2=0.603$ with an edTPA mean score of 42.34. Means of the independent variables listed respectively were 3.59, 7.06, 3.56, and 7.06. VIF of all independent variables < 1.39. Durbin-Watson=2.347. Regression assumptions met.

Two unit plan scores were missing from one cohort, we attribute this to a Livetext error in saving rubric scores rather than reassessing at a much later time from the original scoring.

First, we recognize a non-significant constant, indicating we would expect the edTPA score to be no different from zero without any of the junior/senior year coursework in mathematics education. Given the experiences in mathematics education, the constant then plays a role. The edTPA scores can range from 15 to 75 with 37 being the minimum most states are currently using with a high bar of 42 as cut score for consideration (edTPA, 2017). Most notable, is the closeness of the standardized independent variable coefficients, indicating a relatively equal effect size on the edTPA score. Specifically, three indicators from the unit plan and hallmark lesson plan rubrics used for NCTM SPA accreditation (two major final exam-like assignments) carry about 3/4 of the contribution to edTPA scores (<http://bit.ly/MTEP-Paper-Rubric>). The remainder of the edTPA score comes from the clinical experiences course in which the MCOP² observation scores are worth 40% of the grade and another 25% for the accompanying lesson plans for the observed lessons (most of the course grade variance). The remaining 35% comes from professional experiences, an evaluation from the cooperating teacher and attending the state mathematics conference.

Overall, we see 60% of the variance explained in edTPA outcomes by semester two and three math methods course final assessments (NCTM SPA assessments), as well as the overall professional experiences

discussed within the clinical experience course. We see positive contributions to edTPA scores from semester two's hallmark lesson plan of 19.5 points, an additional 6.5 points from semester three's unit plan, and nearly 10 points from the clinical experiences course. Overall, without considering the constant, these experiences total 36 points just at the minimum for passing. The constant brings this total to the mean 42+ near the high bar recommendation by edTPA.

Summary and Limitations

Strengthening these results, TCs were scored on the hallmark lesson plan rubric by two different faculty. About three-fourths of the clinical grading was done by one faculty member, while that faculty member scored about one-fourth of the unit plans. The second faculty member scored the remainder of each for the entire set of graduates. Two different faculty scored these significant assessments at different times without interrater discussion sessions. This demonstrated the robustness of these assessments across different raters. Largely, we interpret our findings that capstone mathematics courses taught with (1) rigorous assessments that differentiate grades, (2) an ALEKS supplement for improving basic knowledge and skills of the 6–12 curriculum, and (3) advanced perspective of secondary math content strongly contributes to Praxis II scores. Sequentially taught, math methods courses taking TCs from introductory lesson planning, to strong lesson planning, to unit planning results in a strong contribution to edTPA outcomes, as well as a slight impact on Praxis II scores when methods focus on strong uses of technology in teaching and learning mathematics (midterm exam).

We do acknowledge the limitations thus far with plans for advanced analyses upcoming. Converting Praxis II scores in cohort 1, as well as TWS to edTPA scores in cohorts 1, 2, and some of 3 and 4, provides a limitation. Given the strength of the models, we find this limitation less worrisome, but we do recognize the constraints.

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Learning Assistants' Conceptualizations of Equitable Access in Active Learning Mathematics Contexts

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Introduction

The Mathematics Academic Resource Center (MARC) within the University of Colorado Boulder (CU Boulder) mathematics department employs undergraduate learning assistants (ULAs), undergraduate tutors, and graduate student tutors to provide academic support and tutoring to students enrolled in mathematics courses at CU Boulder. The tutors working in the MARC who are not ULAs are predominantly, though not exclusively, students who are majoring in mathematics or a math-heavy science field. The ULAs are mostly freshmen or sophomores who work as assistants in active-learning lab sections of a course they have just completed as students. They also work as tutors in the MARC. Many of the ULAs have not yet declared a major. Some ULAs have entered their position because of an interest in teaching mathematics, and some develop an interest in teaching as a result of their experiences as ULAs.

This paper reports on the results of a study designed to answer the following research question: In what ways do graduate teaching assistants (TAs), ULAs and undergraduate students employed as tutors in the MARC currently conceptualize teaching for equity and access in the context of active learning classroom environments? The paper also reports on the design and implementation of a series of seminars to support ULAs and tutors in their roles working as tutors in the MARC by clarifying and deepening their understanding of how math is taught and learned, and shares insights gained during the study regarding the role of the MARC community within MARC employees' experiences in the broader mathematics community.

Active Learning Context

The work of this project is situated within the context of the CU Boulder mathematics department, which has been working to increase the use of teaching techniques consistent with design principles for active learning (Webb, 2016) and reform-based teaching. Design principles for active learning, described by Freeman et al. (2014) and explicated in detail by Webb (2016), are based on the development of an overarching mathematical coherence within a particular course, as well as specific characteristics within and across courses. Students should participate in activities which depend on the application of reasoning and sense-making skills that go well beyond recall. "Reasoning-in-process," including partially developed conjectures, explanations and representations of solution strategies" (p. 2) are valued components of desirable discourse patterns. Multiple modes of instruction are supported with a focus on eliciting peer-to-peer interaction but explicitly not limited to small-group work, and instruction should be deliberately student-centered, favoring "the perspective of the learners" (p. 2).

The CU Boulder mathematics department's change initiative has been most pronounced in the Precalculus through Calculus 2 (P2C2) course sequence, but the influence of this effort extends to numerous other courses. The primary strategy for accomplishing change has been the adoption of small class sizes and the development of "low instructional overhead" (Webb, 2016, p. 63) activities, which can be implemented by course instructors and teaching assistants with a low level of training or advance preparation. This strategy has resulted in high levels of implementation (Webb, Stade, & Grover, 2014) in the lab sessions of the P2C2 course sequence that are taught by TAs with ULAs as assistants. One impact of this strategy is that TAs and ULAs implementing these

techniques are able to do so with limited foundational knowledge in design principles for active learning on which activities are based. They may also have limited understanding of theory or effective teaching strategies to support equitable access.

Data collected for SEMINAL, a large-scale multi-institution research project, in the spring and fall of 2017 has shown significant differences between females and students of color and their white male peers on measures of positive experiences and sense of inclusion in active learning university Precalculus and Calculus courses. These results reflect students' responses to survey questions administered in P2C2 courses at six universities. Members of underrepresented groups in mathematics indicated significantly lower sense of inclusion and less positive experiences in their math classes, as compared to their white male peers (Voigt, 2017).

This finding is particularly noteworthy in light of research in active and inquiry-based learning contexts that shows numerous positive outcomes resulting from active learning. These outcomes include increased persistence to further coursework in mathematics (data collected in the Spring 2017 CALCS post survey for the SEMINAL project); significantly increased exam scores and concept inventory results, and significantly decreased withdraw and failure rates (Freeman et al., 2014); learning gains in cognitive, affective, and collaborative areas for both women and men, and an elimination of the gap between women and men (Laursen, Hassi, Kogan, & Weston, 2014). The positive outcomes are clear, but it is critical that we attend to the task of understanding why members of underrepresented groups in mathematics describe their experiences in these classes less positively than their white male peers. The results reported in this paper support the development of increased understanding of whether and how ULAs and tutors can play a role in supporting math learning experiences to be more uniformly positive for all students.

Theoretical Framing and Literature Review

Learning is understood to be socially constructed (Palincsar, 1998), and students' learning in reform-based mathematics classrooms is highly influenced by the conversations and activities in which they take part, as well as their own roles within those conversations (Yackel & Cobb, 1996). Students who participate in active learning environments, and who become central participants within those communities (Cobb, Stephan, McClain, & Gravemeijer, 2010), take up a form of mathematics learning that supports the development of a mathematics identity, or the ability to envision themselves pursuing further study in mathematics or STEM fields (Boaler & Greeno, 2000; Cobb & Hodge, 2002). Applying this theory to lesson design supports shifts toward student-centered, active and inquiry-based instruction, and ULAs have played critical roles in implementing such instructional techniques in mathematics courses at CU Boulder.

Boaler (2002) claims that reform-based mathematics teaching, of which active learning is one example, has been shown to be promising, but inconsistent in its promotion and support of equitable access to mathematics learning opportunities. Concerns have arisen in reference to the experiences of numerous historically marginalized populations including racial and ethnic minorities, females, and students from working class or lower socioeconomic status backgrounds (Ball et al., 2005; Boaler, 2002; Delpit, 1988; Lubienski, 2000; Parks, 2010). Evidence shared earlier showing variations in experiences in P2C2 courses further justifies these concerns.

Since reform-based learning experiences in mathematics have been shown to provide greater access to participation in science, technology, engineering and mathematics (STEM) communities (e.g. Freeman et al., 2014), Boaler (2002) claims that further research is needed to identify characteristics of reform teaching that support equitable access for all students in these learning communities. I suggest that ULAs could play a valuable role in shifting aspects of the learning environment in active learning mathematics courses to promote equitable access for students who are members of underrepresented groups in mathematics.

Conceptual Framing: Identity and Sense of Belonging

To support increased understanding of how ULAs and tutors can promote equitable access to mathematics, I propose considering *identity as a doer of mathematics* and *sense of belonging in mathematics* as separate constructs that together form a more robust conceptualization of mathematics identity. The Mathematical Association of America (MAA) implies such a distinction in the Instructional Practices Guide (2017) when they ask, “In what ways does this course design recognize students’ membership and positioning in society and work toward the development of positive social and mathematical identities?” (p. 123). The MAA takes up work by Gutiérrez (2009) and offers the following definition of identity: “This refers to who are our students, including the resources and ways of knowing they bring to the learning environment and who they become through their participation in mathematics” (p. 122). The phrase “who they become through their participation in mathematics,” attends to mathematics identities broadly, while referencing “resources and ways of knowing they bring to the learning environment” indicates concern for students’ ability to bring all aspects of themselves into the classroom. Students must be able to bring their personal identities with them into mathematics spaces in order to develop a sense of belonging in mathematics.

Research is beginning to demonstrate the critical role sense of belonging in mathematics has on persistence in math or science. Good, Rattan, and Dweck (2012) studied the relationship between students’ sense of belonging and decisions about whether to continue in mathematics. Analysis of results from a survey taken by 997 students (465 men and 532 women) during a Calculus course at a highly selective university in the Northeast United States resulted in the claim that “sense of belonging to math – one’s feelings of membership and acceptance in the math domain” was established as a “new and important factor in the representation gap between males and females in math” (p. 700). The work by Good et al. shows how previous work done by Hausmann, Ye, Ward Schofield, and Woods (2009) on the relationship between sense of belonging and institutional commitment applies to mathematics.

These studies make clear that students’ sense of belonging in mathematics is related to persistence in mathematics, and they begin to attend to sense of belonging as separate from identity as a person who does mathematics. The work reported on in this paper represents an effort to understand if and how ULAs can positively impact social factors in math spaces that might influence students’ development of both sense of belonging in mathematics and identity as people who do mathematics. The work has evolved to also consider the degree to which the experience of working as a ULA might contribute to the development of sense of belonging and/or a positive math identity for the ULAs themselves.

Data Collection Methods and Procedures

Data collection included of a variety of strategies designed to support increased understanding of MARC employees’ conceptualizations of teaching for equitable access in active learning contexts. Data consists of survey results, notes and one recording of interviews with MARC student employees; notes on numerous informal interviews and conversations with the MARC director; limited notes (since I was also a facilitator) taken during seminars; and field notes on observations of the MARC space. Data analysis focused on significant results that emerged in any one data source as well as themes that emerged across data sources.

The Conceptualizations of Equitable Practices for Teaching (CEPT) survey was developed and distributed to 60 undergraduate student employees of the MARC for the purpose of gaining understanding of their conceptualizations of teaching for equity and access in active learning contexts. A high response rate of almost 75% (44 students) was achieved. After removing incomplete responses there were 44 completed surveys including 27 ULAs, 14 undergraduate tutors and three front-desk greeters. The ULAs included 15 females, nine males, two

students who responded “gender diverse,” and one student who did not answer the demographic questions. Two thirds of the ULA group self-identified as “completely” or “mostly heterosexual or straight,” while 13 of 14 tutors self-identified as “completely” or “mostly” heterosexual or straight. The tutors included four females and 10 males. Both the ULA and tutor groups were approximately three-fourths white. The three front desk greeters all self-identified as white females. It is worth noting that the fall 2017 ULA group was 48% female and 45% non-white, while the fall tutor group was 25% female and 20% non-white. During the 2017–2018 academic year, the ULA group included a larger percentage of students who were members of underrepresented groups in mathematics than did the non-ULA tutor group.

Two 60-minute semi-formal interviews were conducted with learning assistants (one white female and one white male) during the Spring 2018 semester, and one 20-minute informal interview of a front desk greeter (an ethnic minority female) occurred during the Fall 2017 semester. Notes were maintained for each interview and the final interview was recorded.

The MARC director and I facilitated three two-hour seminars, two in the Fall 2017 semester, and one in the Spring 2018 semester. At least one additional seminar was facilitated by the MARC director. This seminar was not considered as part of this study. For each seminar, I noted interactions and characteristics that seemed important in the moment and wrote a brief memo after the seminars were over. During the spring semester we also maintained a Google document into which seminar participants directly entered some of their responses and ideas during discussions.

I observed the MARC space at a variety of times of day, days of the week, and times that were either immediately before a major exam or particularly quiet. Each of these observations were at least one hour and up to two hours in length. Field notes were taken for each observation. Data collection also included numerous informal conversations with the director of the MARC, which took place between late Spring 2017 and April 2018. I took notes with varying levels of detail during these conversations.

Evolution of the Seminars

The seminars designed as part of this study were intended to provide opportunities for ULAs and tutors to develop greater understanding of teaching for equitable access in active learning contexts, with a focus on their roles as MARC tutors. ULAs also enroll in a 1-credit course that supports them in developing an understanding of teaching pedagogy related to their roles as classroom assistants, but this does not address the tutoring context. It was hoped that the seminars would also foster deeper relationships among undergraduate and graduate students and help shape MARC culture to be more inclusive.

The first seminar was implemented as a large-group meeting in September 2017, and all MARC employees were required to attend. Reflection after this seminar led to the conclusion that it included too many participants to be effective, so in October 2017 a seminar focused explicitly on teaching for equity and access with a smaller group of MARC employees, which included only the undergraduate tutors and ULAs, was implemented. Attendance was optional for graduate tutors and very few attended. A significant portion of this time was focused on presentation of key ideas and large-group discussion about the terms “identity” and “sense of belonging,” as well as asset-oriented approaches to teaching and interacting with students.

This particular seminar developed an impromptu focus on mathematical conventions that grew from questions and comments raised by participants. This conversation centered on making sense of the purpose and value of conventional problem-solving methods as compared and contrasted with methods that are unconventional but mathematically accurate. The conversation remained attentive to questions about increasing participation in mathematics, and it felt productive and thought-provoking despite lack of clear consensus or

conclusions regarding the emergent questions. There were also significant imbalances with regard to who participated in the group discussion, and the ULA group participated noticeably less than the tutors.

The final phase of seminar implementation for the 2017–2018 academic year occurred in early February 2018 for an even smaller group—approximately 30 undergraduate MARC employees—including all of the ULAs for P2C2 courses, a few ULAs for other courses, and a subgroup of the non-ULA undergraduate tutors. The topics included much of the content from the fall equity-oriented session as well as discussion of emerging early semester questions and concerns. As facilitators we intentionally circulated through the room collecting and sharing out comments from participants to assure that a broad representation of ideas and experiences would be heard.

Conceptualizations of Equitable Access in Active Learning: Survey Results

The first two sets of survey prompts consist of questions about ULAs' beliefs regarding the importance of certain student perceptions. These questions ask if tutors see benefit to students believing that their ideas are valued, students believing they can get help and get questions answered, and students believing that others are encouraging them to do well in mathematics. Over 70% of ULAs and tutors responded "very important" or "somewhat important" to each of these prompts.

Both ULAs and tutors were divided as to whether "it's important for all students to participate equally during small-group discussions," but 79% of ULAs and 73% of tutors disagreed with the statement, "it's okay if a few students answer almost all the questions during class discussions." All ULAs and tutors agreed or strongly agreed with the statement, "it's important for students to receive positive or encouraging feedback on their math work." Conceptualizations of active learning and teaching for equitable access, at least to the degree these are represented by these survey responses, appear to be consistent among MARC ULAs and undergraduate tutors.

Many of the themes that emerged in seminar discussions are at least partially represented by the concern for student experience indicated in the following comment in the survey open-response question: "I am dyslexic and ADHD and I let my students know this ... so they can feel less intimidated to talk to me and ask me questions."

Varied Experiences of MARC Employees: Survey and Interview Results

My interest in the MARC community's role in the lives of those who work there grew from several factors: (1) the demographics of the ULA group, (2) the MARC director's intention to develop the MARC space as a welcoming and inclusive student community, and (3) my theory that the experience of working in the MARC might contribute to ULAs developing of a sense of belonging in mathematics, a positive mathematics identity and/or increased interest in teaching.

Early indications that the MARC might not be consistently rising to the director's inclusive vision arose in the fall seminars when the older tutor group dominated the conversation. One small group of tutors was overheard stating, "I'm a math guru," and "Yah, I'm definitely a math guru!" These comments seemed to indicate a degree of status that working as a MARC tutor could confer, but the dynamics of the seminar in which these statements were made led me to wonder if the younger and more diverse ULA group had access to this degree of status. One female third-year tutor's response to the open-response question on the CEPT survey stated, "There are some very arrogant and pretentious male tutors in the MARC who seem to intimidate and/or discourage students and other co-workers in the MARC from engaging in a discussion about math." A large and diverse set of respondents also wrote statements such as, "I really love it," and "This has been an awesome experience for me and I love that I was given a chance to LA Math even though I do have learning disabilities and Math isn't something that comes super easy to me."

Interview data from a conversation with Lisa (a pseudonym), a second-year math education major working as a ULA included a number of interesting statements. In describing her choice to pursue a math major Lisa stated, “I’m so good at it [math]” and says that she “loves math,” both of which indicate the strength of her identity as someone who does mathematics. She refers to her sense that “women in STEM are looked down on” as well as experiences such as looking around and noticing only male students in math spaces, both of which demonstrate ways that she experiences constraints on her sense of belonging in mathematics.

Analysis and Conclusions

This project has resulted in evidence that many ULAs and tutors hold views of active learning and teaching for equitable access that are likely to support positive, encouraging, and asset-oriented interactions with students in the MARC and in mathematics classes. Interactions such as these may, at least in some cases, contribute to an increased sense of belonging and positive mathematics identities for mathematics students and possibly a more robust persistence in mathematics that extends beyond P2C2 courses.

This study has also produced evidence that many ULAs and tutors in the MARC benefit from their experiences in ways that support their own sense of belonging in mathematics and positive mathematics identity, even while recognizing that the MARC community is not universally positive for all members. Work still needs to be done to improve the consistency of these experiences. The demographics of the ULA group and the fact that ULAs often either assume their roles because of their interest in teaching or become interested in teaching during their time as ULAs, points to the importance of attending to the MARC community dynamics in ways that may improve the consistency of positive experiences. The fact that ULA group includes a relatively high percentage of students who are members of underrepresented groups in mathematics means that improving the experience of being an employee in the MARC is a potential opportunity to impact the experiences of a more diverse population of participants in mathematics who may eventually become teachers.

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A Statewide MTE-Partnership Collaboration (or Hui) in Hawai'i

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Introduction

In Ōlelo Hawai'i (the Hawaiian language), “hui” is used to name an organization, association, or partnership. The phrase “a hui hou” is commonly used to express “until we meet again” though it might be better understood as “until we join together again.”

The state of Hawai'i has a single public university system (University of Hawai'i) composed of 10 campuses across the Hawaiian Islands—three universities and seven community colleges—several of which offer four-year degree programs. At the K–12 level, all public schools are part of a single school district. Beyond these two statewide systems of public education, there are several private universities and K–12 schools.

Since the University of Hawai'i (UH) joined MTE-Partnership in 2015 (as “MTE-P Hui”), participation had focused around the efforts of three faculty at the Mānoa campus on O'ahu and one at the Hilo campus on Hawai'i. We have been active in three MTE-Partnership Research Action Clusters (RACs) and one working group (Actively Learning Mathematics, PR², STRIDES, and the Equity and Social Justice Working Group), each of us traveling to a previous MTE-Partnership Conference or RAC meeting as well as participating in online-based activities throughout the year.

Challenge and Purpose

While each of us was passionate about the work and the partnership, we realized our reach and impact were limited. We also expressed concern that, as is, pursuing the MTE-Partnership goals relied completely on the voluntary participation of just four UH faculty, faculty with full workloads and commitments.

In Hawai'i, our geographic isolation has fostered a reliance on 'ohana—extended family. As educators, this translates to looking to our 'ohana to ensure we are providing our keiki, our children, with a strong education. As our active members of MTE-P Hui at the University of Hawai'i considered how we might address our Hawai'i needs in terms of the recruitment, preparation and retention of high quality mathematics educators, we saw the value in reaching out to our 'ohana of educators across the state.

Our Plan for Transformation

During the summer before the 2017–2018 academic year, the authors, MTE-P Hui participating faculty at the Mānoa campus, conceived of a four-session conference series to span nearly seven months as a means to involve more of our mathematics education 'ohana in the work of MTE-Partnership.

Consistent with the MTE-Partnership Guiding Principles (2014), we set out to grow our MTE-P Hui and asked the following guiding questions:

1. How can we broaden and strengthen our collaboration with stakeholders across institutions in Hawai'i? (Guiding Principle #2: Enhancing communication among partners)
2. Who are we as an MTE-P Hui in Hawai'i and what do the national driver diagrams mean to us locally?

3. How do we establish a framework for the use of local, relevant data to inform our goals and actions? (Guiding Principle #3: Establish a framework for local research)
4. What can we learn from the experience of scaling up our MTE-P Hui? (Guiding Principle #1: Contribute to the national conversation about effective practices; and Guiding Principle #4: Sharing resources)

In this paper, we will describe how we moved from a small group of UH faculty involved individually with MTE-Partnership to a stronger MTE-P Hui including stakeholders from across Hawai'i. We will share our considerations and logistics in establishing the 2017–2018 MTE-P Hui Conference series, how our guiding questions contributed to the plan and design of each conference session, and what we learned from our transformation and discuss our next steps as a Hawai'i MTE-P Hui.

MTE-P Hui Conference Series

Our motivation for the conference series was based in recognition that the UH system alone was not sufficient to address the goals of increasing the number of high-quality mathematics teachers educating our keiki. Our reach and impact, acting alone, is limited. In addition, we recognized that we needed to expand the leadership capacity of our MTE-P Hui to establish a framework through which the work could continue as new leadership emerged and not be dependent on the participation of a small group of UH faculty. We were interested in how we could foster participation, action, and leadership from interest in the MTE-Partnership work expressed by members of our mathematics education 'ohana.

Considerations. Three foci emerged in our early planning for the conference series: (1) the importance of spending time establishing a sense of identity as a MTE-P Hui, (2) focusing efforts around the existing RAC structure of MTE-Partnership, and (3) embracing Improvement Science (Bryk, Gomez, Grunow, & Lemahieu, 2015).

Each of the authors had spent time interacting and collaborating with partners across the country in the MTE-Partnership, but we had not had an opportunity to think collectively about how this work might translate (or not translate) to a Hawaiian context. Therefore, we understood it would be important to spend some time establishing our Hui's identity and purpose specific to our unique needs in Hawai'i, to welcome and value what is referred to as a Sense of Place, a Sense of Purpose in traditional modes of learning in the Hawaiian culture. We used the national MTE-Partnership RAC driver diagrams to help us think about our local context and identify the assets we might leverage toward initiating change.

Uncertain about the amount of participation we might expect in the conference series, and motivated to position ourselves to engage in actionable, measurable projects, we choose to adopt, as an organizational starting point for our Hui, the existing MTE-Partnership RAC structure. While we aspired to have sufficient participation to warrant RACs within our Hui (referred to as Hui RACs) for each of the five national RACs, we chose to focus—at a minimum—on the three RACs and one working group with which we had been individually involved: Actively Learning Mathematics, PR², STRIDES, and the Equity and Social Justice Working Group. We wanted to keep our scope feasible and within our existing knowledge and experience with MTE-Partnership.

Our third focus was on a responsible use of data to inform our plans and actions. We respected the Plan-Do-Study-Act (PDSA) model as a means to ensure our efforts were connected to our goals and needs and were measurable. We understood the need for our Hui to be able to engage in a common “language” around the use of existing data and actionable, quantifiable goals. We incorporated time within each conference meeting to learn and practice together following the principles of Improvement Science to ensure fidelity in our use of the PDSA model.

We also discussed the likelihood for our Hui to grow and evolve as inspired by our new leader members—even if that growth was in directions different from what we had anticipated.

Logistics. During the summer preceding the 2017–2018 academic year, freshly inspired by attending the MTE-Partnership Conference in New Orleans, Louisiana, Charmaine Mangram and Linda Venenciano at UH Mānoa conceived of the idea of a conference series spanning the academic year. They invited Jim McKown, also at UH Mānoa, to join in the planning and we started the process of establishing an MTE-P Hui Conference. Our proximity and the willingness to make time in our schedules to plan and lead the conference series contributed to our de facto roles as “Hui” leaders. We met in person or on Zoom (<http://zoom.us>) generally twice before each conference date—the first time to determine our goals for the session and to assign tasks (logistics and planning), the second to finalize agenda and activities for the session.

Considering our goals for the conference series, we decided to strive for four Saturday meetings about two months apart spread throughout the 2017–2018 academic year. With consideration for the likely availability of other mathematics educators from across Hawai'i, we determined to reach out to the Hawai'i P–20 Partnerships for Education (typically referred to as Hawai'i P–20) about having our first session, an informational meeting, as a conference-within-a-conference, during their annual Math Summit in November 2017. For a January conference date, we again considered the conference-within-a-conference structure and approached the Hawai'i Educational Research Association (HERA) about overlapping with their annual conference. The March and May dates were chosen around the schedules of the three of us for lack of any other compelling rationale.

From the beginning, we realized our funding opportunities would be increased by framing the Saturday meetings as a conference or conference series. We solicited and generously received financial and organizational support from the leadership of MTE-Partnership national, Hawai'i P–20, the College of Education (COE) at Mānoa, the COE Curriculum Research and Development Group (CRDG), and independent private consultant Rich Seder. Among the three of us, we split up the task of reaching out to each of these groups and individuals for support based on existing connections or relationships keeping the others updated by email as we secured support. Table 1 provides an overview of each day of the conference series.

Table 1
Conference Overview

Date/Location	Goals and Activities
Day #1: Nov. 9, 2017 Math Summit, UHWO	Disseminate and promote the work MTE-Partnership and MTE-P Hui Recruit additional MTE-P Hui participants
Day #2: Jan. 13, 2018 HERA, UHM Campus Center	Establish a collective identity as an MTE-P Hui Introduction to Improvement Science
Day #3: March 3, 2018 DOE facilities	Continue to establish a collective identity Introduction to driver diagrams and improvement science review protocols Decide on next steps for MTE-P Hui and Hui RACs
Day #4: May 5, 2018 UHM COE	Establish leaders for each RAC Commit to researchable change ideas that each member can carry out Decide on virtual meeting schedule for each RAC Provide brief summary of the work carried out through the conference Discuss MTE-Partnership Summer Conference Opportunities

What We Have Learned

The following are brief discussions of what we learned from our first year organizing the Hawai'i MTE-P Hui Conference framed within the questions that guided our planning and implementation.

1. How Can We Broaden and Strengthen Our Collaboration with Stakeholders Across Institutions in Hawai'i?

This year has been marked by creative partnering. Our Hui partnered with a number of organizations and departments both inside and outside of the UH system. We garnered both financial and informational support from the leadership of the MTE-Partnership national organization and Hawai'i P-20. Together these two organizations committed a total of \$4,000 for this year's conference activities. In addition to named financial partners, we partnered with HERA, the Hawai'i Department of Education (HIDOE), and University of Hawai'i at Mānoa's COE CRDG. HERA provided support by incorporating an improvement science workshop into their 40th annual conference specifically for our members. HERA also waived the conference registration for our members to attend the annual conference. CRDG faculty members Thanh Truc Nguyen and Rich Seder have served as improvement science coaches for our Hui this year.

In addition to monetary and informational support, our partners have provided facilities support, primarily through our creative use of a "conference within a conference" model. This conference within a conference model allowed us to save money and also allowed us to leverage the administrative work of our partners who already had the capacity to plan and run their own conferences. For example, we hosted our first conference within the Hawai'i P-20's Annual Math Summit at UH West Oahu's campus. In addition, our second conference was hosted within the 40th annual HERA conference on campus at UH Mānoa.

We assumed that one of the greatest challenges that potential participants might face is the inability to commit to several all-day Saturday conference meetings. Therefore, our leadership team envisioned a flexible participation model in which potential MTE-P Hui members could select their own level of involvement. This year, there were two levels of commitment, "Working Group Members" and "Hui Supporters." Table 2 outlines the roles and responsibilities at the two levels of commitment.

Table 2

MTE-P Hui Participation Levels

Working Groups Willing to Meet	Hui Supporters Willing to Support
Meet three times in the Spring/Summer 2018 Possibly read a few documents and/or complete tasks between conference meetings	Might be contact people at your institution Willing to try out ideas at your institution Want to be kept in the loop

Our initial approach to recruitment was a success. MTE-P Hui has now expanded our membership to include a greater variety of stakeholders. In addition to adding faculty members from our own College of Education, we now have members from UH West-Oahu, UH Hilo, Kapiolani Community College, HIDOE, and the non-profit organization, Education Incubator.

Our "Working Group" members have increased from the original four UH faculty (three at UH Mānoa and one at UH Hilo) to 10, including mathematics faculty at Kaua'i Community College (on Kaua'i), Kapiolani Community College (on O'ahu), faculty in the Mathematics Department at UH Mānoa, and additional UH Mānoa COE faculty. Our "Supporters" make up another eight to 10 and include representatives from Hawai'i P-20, HIDOE (high school mathematics teachers as well as district support staff), a former private school mathematics teacher (now with Education Incubator), faculty at UH West O'ahu, and additional UH Mānoa COE faculty. Most of the Working Group participated in all of the conference series sessions. Some supporters were also able to attend a

session or two though many just requested to be kept informed of our progress and projects as we start PDSA cycles.

Our current Hui RACs have two, three, or four contributing Working Group members each. Several of us have identified as a Working Group member of one Hui RAC and also a Supporter of one or more of the other Hui RACs.

2. Who Are We as an MTE-P Hawai'i and What Do the National Driver Diagrams Mean to Us Locally?

In planning for our MTE-P Hui conference series for 2017–2018, we believed it was important to embed a sense of local identity. We planned for time to reflect on the goals (driver diagrams) at the national MTE-Partnership level and allowed for new Hui members to voice their perspectives about how those goals connected with our local needs.

We began conference Days 2 and 3 with activities that would help our newly forming Hui identify our own local goals, needs, and interests within the larger national MTE-Partnership context. We began Day 2 by asking the group: *What are 3 words or phrases that represent your values/goals for the MTE-P Hui?* As participants responded to the prompts, a Wordle (<http://www.wordle.net/>) was produced. The Wordle (see Figure 1) allowed participants to see connections between their own individual interests and values and those of the other participants.



Figure 1. Visual Representation of Values/Goal of MTE-P Hui Participants

In the discussion that followed this activity, we identified the following themes that we might collectively explore throughout the remaining conference days: Networking, retention, the 12–college transition, training of teachers, addressing issues of equity in HIDOE teacher placement, exploring pathways to becoming a math teacher, and influencing how mathematics is viewed and how the profession of mathematics education is viewed in the public sphere.

To help us further articulate our collective vision for the Hui, on Day 3, we asked participants: *Where are some of our strengths? What are we already doing well?* Participants responded that one of our greatest strengths was our collective focus on place-based and culture-based approaches. For example, all of the participants were

actively seeking to incorporate Nā Hopena A'o (HĀ)¹ into their own work at their various institutions. Another strength we identified was our interest and ability to collaborate across stakeholders. We envisioned that we might be able to leverage current public relations inter-institutional initiatives in Hawai'i such as [Grow Your Own](#) and [Be a Hero, Be a Teacher](#) into our Hui RAC work.

After discussing our collective strengths, we shifted to thinking about our areas of need. We asked participants: *Where are the gaps?* In other words, we wanted to collectively identify our state's needs in relationship to recruiting, preparing, and retaining high-quality secondary mathematics instructors. The two most frequently occurring needs were related to limited resources (time and money). As a Hui, many felt that we would need much more time to identify change ideas, gather data, and test our ideas. The other concern was related to Hawai'i's ability to recruit and retain high-quality teachers over the years. We face the harsh reality that low teacher salaries coupled with a high cost of living in Hawai'i may be a disincentive to many potential teachers given that other math-related careers are much more lucrative. We asked ourselves, what is our role in ensuring that, in future years, Hawaiian teachers are able to live comfortably?

In Days 2 and 3, we also spent a great deal of time developing a collective understanding of improvement science and the national MTE-Partnership driver diagrams. On Day 2, Dr. Seder facilitated an introductory session on improvement science and the PDSA cycle. Between Days 2 and 3, via email, we shared with potential conference participants the national driver diagrams and asked them to bring their questions and wonderings to Day 3. On Day 3, Drs. Seder and Nguyen led a workshop on driver diagrams. During this workshop, we learned to read a generic driver diagram, and we collectively analyzed the national MTE-Partnership driver diagram and the national RAC driver diagrams that were available online.

The national driver diagrams provided our team with a starting point for conversations about possible directions for our Hui. The drivers and paths through the drivers confirmed some of our intuitive ideas about how improvements could be attained, and, at the same time, raised questions about the relevance to our local context. Along some of the depicted paths we recognized relevance and a good fit for our context, but along other paths our team questioned their own influence on the dynamics related to the drivers.

For example, the driver diagram for the STRIDES RAC includes a secondary driver on implementing a professional development continuum. The majority of our team members are from higher education institutions. Their potential for influence is somewhat hampered by existing structures the schools and districts have implemented to induct and mentor all new teachers. Through conversations with our K–12 supporting team members, our team learned that these induction structures were designed for the general audience of new teachers and not tailored to subject areas or grade spans. As we explored the potential to collaborate with the mentors who led induction and mentoring programs with new teachers across the state, we became aware of unspoken priorities that shaped the culture of these programs.

Although our team has not carried out an in-depth analysis of the national driver diagrams, we have begun focused discussions on specific change ideas. Designing driver diagrams informed by our local context is a task we are considering for the future.

3. How Do We Establish a Framework for the Use of Local, Relevant Data to Inform Our Goals and Actions?

With a focus on actionable steps, our Hui embraced the six principles of improvement science as a methodology for proposing and tracking change over time. We believed that developing a common understanding and language among the growing hui around the strategies of improvement science will allow us to move toward

¹ An HIDOE department-wide framework to develop the skills, behaviors, and dispositions that are reminiscent of Hawai'i's unique context, and to honor the qualities and values of the indigenous language and culture of Hawai'i.

establishing data-based research cycles within each Hui RAC. We recognized that a common methodology would allow us to move beyond the isolated, often uncoordinated efforts of individuals to address the need.

The improvement principles articulated by Bryk et al. (2015) have been useful in guiding the work of MTE-P Hui and has aided our efforts to define who we are as a partner of the MTE-Partnership. Specifically, to better understand our context and the conditions that produce the teacher shortage in our state, we have focused our efforts on contacting and recruiting individuals who represent different sectors of our state education system. Through our membership we have begun to understand problems that plague our education system and discuss solutions that could potentially be exported to other contexts. For example, the RACs of MTE-Partnership have helped us organize ourselves around parallel interests within our MTE-P Hui. We formed Hui RACs, smaller-scale versions of the national MTE-Partnership RACs, and are encouraging the members of the Hui to identify with at least one Hui RAC. This has helped us identify the interests and potential influence of our membership.

Another component of the improvement science work that we have found applicable to our work is the PDSA cycle. The PDSA cycle is described as a basic method of inquiry in improvement research and follows a logic of systematic experimentation in the context of everyday practice (Bryk et al., 2015). A PDSA cycle should target a small change idea for a process or outcome. The cycle is intended to be iterative and therefore results from the change may not be clear until multiple cycles have been completed. The simplicity of the PDSA cycle makes it tempting to embrace and implement. But as we have discovered through our Hui conference sessions, deciding on a change idea is not a trivial process.

Day 4 of our conference series saw each Hui RAC identify targets for an initial PDSA cycle. We had the opportunity for Gary Martin and Marilyn Strutchens of Auburn University to join us and provide support and guidance to our efforts. Our Hui RACs all got started on a PDSA cycle with an emphasis on aiming for something meaningful and achievable given our resources.

4. What Have We Learned from the Experience of Scaling Up Our MTE-P Hui?

One of our greatest takeaways from this year relates to the power of creative partnerships. Although we were able to successfully solicit funding that allowed us to pay for meals and inter-island travel (for one participant), our creative partnerships afforded us the ability to do much more. By partnering with organizations who were already planning their own conferences, we were able to take advantage of the facilities and administrative resources of larger organizations. This was especially important given that many of our potential participants would already be planning to attend the larger events. This type of partnering also led to an increased visibility of our work to other key educational stakeholders in Hawai'i.

Another key finding is that the weekend working conference format seemed appropriate for the majority of participants. With the exception of the Missile Threat false alarm (Boboltz, Herreria, & D'Angelo, 2018), we had very consistent attendance at the sessions, and all participants came on time and stayed for the whole conference. One question that we are asking ourselves is, how can we make this more sustainable? One way to do this is to decrease the funding and administrative support needed to host the conference in upcoming years. Strutchens suggested that we consider adopting a "brown bag format" in future iterations of the conference, which seems like a feasible idea and one we recommend to others as they contemplate adopting our model. Relatedly, one of our improvement science coaches wondered whether the term "conference" was appropriate. However, our early success seems to indicate that the term conference might be critical in soliciting support (funding and administrative) from those who are less familiar with MTE-Partnership and its goals. Given the continued support we have received from national MTE-Partnership and our local partners, we feel validated that this is an appropriate plan and potential model for other institutions.

Another question we asked ourselves as we planned this year was the appropriateness of devoting so much time to learning about improvement science. Given that two of the three MTE-P Hui leaders had no prior experience with improvement science, we concluded that this was, indeed, a good use of time. Having a shared understanding of improvement science and PSDA cycles, our team anticipates that this will allow us to avoid some of the pitfalls that would be related to our lack of knowledge. Also, a firm grasp of improvement science methodologies might allow individual Hui members to feel empowered to join national RACs on their own, which was one of our original goals when we began this work. We have already seen some traction in this area, as two of our current members are now considering joining the Clinical Experiences RAC this summer.

Finally, although we were able to increase participation with other faculty across the UH system, we were less successful in increasing involvement from non-faculty (such as the HIDEOE math specialist, college math advisor, STEM Diversity Specialist for the UH Office of STEM Education). While we hoped that having these various stakeholders present would add to the diversity of thought informing the development of our hui, their absence may have inadvertently allowed us to ensure that the concerns/priorities of other entities did not overshadow our original objectives. We plan to continue inviting people in these positions to serve as supporters, but we understand that, for now, the MTE-P Hui membership might consist primarily of faculty.

Next Steps

Given the positive responses, we are planning to continue this conference format in the following year. Now that all current MTE-P Hui members have a shared knowledge of the improvement science processes and the goals of Networked Improvement Communities, our leadership team has decided to move forward with our original plan to devote most of our conference time to Hui RACs. Our next steps will be to encourage Hui RACs to establish regular times and dates to meet outside of “conference” dates. One key factor in our ability to divide into Hui RACs is the identification of facilitators for each Hui RACs. We believe that this is our greatest priority at this stage, as we were less than successful at building leadership capacity/capability this year. Before the start of the Fall semester, our current leadership team will need to: (1) identify possible Hui RAC leaders and (2) create a plan for gradually releasing the responsibilities for MTE-P Hui to the individual Hui RAC leaders.

In addition to developing a leadership plan, we will need to continue to sustain and maintain the partnerships that were established this year. In particular, we must determine whether it is possible to continue to hold our conference within the Hawai'i P-20 Math Summit and also explore other ways to leverage our partnership with HERA. With all the momentum that we have generated this year, we are excited to continue this journey in growing our Hui. We also look forward to sharing this information with the larger MTE-Partnership community at the Seventh Annual MTE-Partnership Conference. A hui hou—until we join together again.

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Secondary Mathematics Teachers' Understanding of the Nature of Mathematics

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Abstract

Pre-service secondary mathematics teachers should develop rich understandings of the nature of mathematics through their completion of undergraduate teacher preparation programs. But what specifically should we be teaching pre-service secondary teachers about the nature of mathematics? And how can we ensure pre-service secondary teachers effectively learn about the nature of mathematics? Researchers in science education are conducting systematic inquiries into teachers' understandings of the nature of science, but comparatively less research on the analogous topic has been conducted in mathematics education. This paper presents findings from an exploratory study, the primary goal of which was to create a humanistic framework for the nature of mathematics that outlines potential goals for students' understanding of the nature of mathematics.

Introduction

The Mathematics Teacher Education Partnership's Guiding Principles for secondary mathematics teacher preparation programs state:

Nature of mathematics: The secondary mathematics teacher preparation program ensures teacher candidates understand, and are able to convey to their students that mathematics is a living and evolving human endeavor that relies on logic and creativity, and it is valuable for citizenship, for the workplace, as well as for its intrinsic interest.

This indicator of Guiding Principle #4, Candidates' Knowledge and Use of Mathematics, emphasizes the importance for secondary mathematics teacher preparation programs to provide future teachers opportunities to learn about the nature of mathematics in ways that will subsequently influence their teaching practice. These opportunities aim to impact secondary students' perceptions of mathematics in productive ways; however, the field of mathematics teacher education still has much work to be done in this area.

Students and teachers may have limited views of the nature of mathematics; they may view mathematical knowledge as static and consider the primary practice of mathematics to be the memorization of rules and procedures (Beswick, 2012; Erlwanger, 1974; Muis, 2004; Presmeg, 2007; Thompson, 1992). These naïve views may negatively affect the teaching (Thompson, 1992; White-Fredette, 2010) and learning (Erlwanger, 1974) of mathematics. These views are referred to as naïve because they are in stark contrast to those held by mathematicians and mathematics education scholars. For example, Boaler (2016) noted,

Mathematics is a cultural phenomenon; a set of ideas, connections, and relationships that we can use to make sense of the world. At its core, mathematics is about patterns. We can lay a mathematical lens upon the world, and when we do, we see patterns everywhere; and it is through our understanding of the patterns, developed through mathematical study, that new and powerful knowledge is created. (p. 23)

Although I am not aware of any studies that specifically describe future secondary teachers' understandings of the nature of mathematics, those of us who teach this group know that many students pursue a mathematics major because they view mathematics as a subject of right and wrong answers for which one must

develop the skill of memorizing and applying correct procedures. Given what we know about future secondary mathematics teachers' prior learning experiences, in which much of their schooling may have included traditional instruction in preparation for standardized tests, many have likely not experienced the creative aspect of mathematics (Burton, 1999).

Coming back to the MTE-Partnership goals, we need to consider this question: What instructional practices are effective to teach future secondary teachers that “mathematics is a living and evolving human endeavor that relies on logic and creativity, and it is valuable for citizenship, for the workplace, as well as for its intrinsic interest”? (MTE-Partnership, 2014, p. 3). What specifically do students need to learn if they are to see mathematics as an evolving human endeavor? We cannot meet this broad goal if we do not express it in more detail. Our field needs a systematic inquiry into the nature of mathematics.

The Nature of Science

If we, as scholars in mathematics education, are to conduct a systematic inquiry into the teaching and learning of the nature of mathematics, we would do well to learn from the field of science education. Within science education, scholars have long recognized that students have many misconceptions about the nature of scientific knowledge and the practice of scientists (Hurd, 1960). For instance, colloquial use of the word *theory* (as a whimsical guess rather than an explanation with substantial confirming evidence), contributes to students' stance that evolution is *just a theory*. To address such misconceptions, and promote a humanistic view of the scientific enterprise, scholars have created lists of goals for students' understandings of the nature of science (Lederman & Lederman, 2014). For instance, the Next Generation Science Standards (NGSS, 2013) contain an appendix that lists, in detail, understandings of the nature of science that K–12 students should achieve. Students should understand, for example, that “Scientific knowledge is open to revision in light of new evidence” (p. 4). The NGSS provides detailed descriptions of how student understandings of these aspects of science should unfold across all K–12 grade levels. In addition to lists that outline goals for students' understanding of the nature of science, scholars are also conducting research to understand students and teachers' conceptions of the nature of science (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). Other studies examine the instructional practices that are effective in teaching specific nature of science characteristics (Lederman & Lederman, 2014). The purpose of this study was to begin the conceptualization of the nature of mathematics as has been done with the nature of science in science education, hopefully leading to a systematic inquiry into the subject.

Methodology

This paper reports on a dissertation study in which I sought to begin a systematic inquiry into the nature of mathematics—analogous to that which is ongoing in science education—and produce the beginnings of a humanistic framework for the nature of mathematics that would be revised in the future. Two main questions guided the study: (1) What is the nature of mathematics? and (2) What should undergraduate students in a transition-to-proof course—including future secondary mathematics teachers—understand about the nature of mathematics?

Before the study was conducted, I conducted a thorough literature review into the nature of mathematics within mathematic education research and selected pieces from humanistic philosophy of mathematics (e.g. Hersh, 1997). For the study, I conducted a heuristic inquiry (Moustakas, 1990), collecting and analyzing data from a variety of sources in order to form a creative synthesis that captures the human essence of the nature of mathematics as it emerged during the study. Describing heuristic inquiry, Patton (2015) noted:

[H]euristic research epitomizes the phenomenological emphasis on meanings and knowing through personal experience; it exemplifies and places at the fore the way in which the researcher is the primary

instrument in qualitative inquiry; and it challenges traditional scientific concerns about researcher objectivity and detachment. (p. 119)

I chose this methodology because I believe that to know mathematics is to do mathematics. In order to personally understand the nature of mathematics, I considered my experience of mathematics in all aspects of my life. I also pursued experiences that would be highly relevant to the nature of mathematics. I studied my own experience doing mathematics through collaboration with a professional mathematician working to prove an unsolved conjecture in graph theory. I documented this collaboration through audio recordings of discussions with the mathematician and hard-copies of all mathematical work. Throughout this work, I considered my two research questions, identifying the meaningful things I was learning about the nature of mathematics and considering what aspects would be valuable for students to understand about the nature of mathematics.

Another key component of data came from an undergraduate transition-to-proof course. Transition-to-proof courses are an important part of many universities' preparation programs for future secondary teachers majoring in mathematics education. In the course that was involved in this study, six of the 23 students were mathematics education majors. The course was co-taught by two mathematics education scholars. The first, an assistant professor of mathematics education, designed and taught the course for seven prior semesters. The second, the author of this paper, was a doctoral student completing this study as a dissertation project. Both instructors frequently utilized their understandings of the discipline of mathematics to help students understand the nature of pure mathematics and proof.

I also collected several other sources of data. I conducted several interviews with mathematicians and others, the general topic of these interviews being the nature of mathematics and students' understandings of the nature of mathematics. I also kept a detailed reflective journal and personal audio recordings, which served as a means to analyze my experience of the nature of mathematics as it unfolded in all aspects of life. The data was analyzed using several qualitative methods, including initial coding and heuristic inquiry methods such as immersion, illumination, explication, and creative synthesis. The product of the study is a list of humanistic features of the nature of mathematics that can be researched as appropriate goals for students' understanding of the nature of mathematics along with real-life narratives, which put these humanistic features into context.

Data Analysis

The key goals of the study were to form a list of characteristics of the nature of mathematics that may serve as goals for students' understanding of the nature of mathematics and to form a creative synthesis (Moustakas, 1990) that consisted of real-life stories grounded in the data that illustrated each of these characteristics, putting a human face on mathematics. In this spirit of heuristic inquiry (Moustakas, 1990; Patton, 2015), I analyzed data both during and after data collection. During data collection, I constantly reflected on what I was learning about the nature of mathematics through data collection and considered what would be valuable for students to understand about the nature of mathematics. Often, I would take the opportunity to discuss my ideas with others during the informal interviews with mathematicians and others, getting opinions about what is valuable for students to understand about the nature of mathematics. By the end of data collection, I had created a large list consisting of possible goals for students' understanding of the nature of mathematics.

After data was collected, my main goal was to finalize a list of characteristics of the nature of mathematics that would be valuable for students to understand, and tell real-life stories using excerpts from my data that illustrated each of the characteristics in the list/framework. To begin this process, I transcribed all of the collected data. I then assigned a code to each possible goal for students' understanding of the nature of mathematics from the list created during data collection. I then used the qualitative data analysis software ATLAS.Ti to code the

entire data set, noting when certain characteristics were reflected in the data. I then wrote stories that illustrated each of the characteristics that were emerging as most meaningful in the study. Lastly, I finalized a framework together with several illustrative narratives.

Results

The list in Table 1 is a major product of the study, which outlines characteristics of the nature of mathematics that may be valuable for undergraduate students—including future secondary teachers—to know and understand. The characteristics and categories should be studied in future research. The list is divided into three sections: Mathematics as a fundamental part of human cultures; the IDEA framework for the nature of pure mathematics; and statistical and applied mathematics. I chose not to include the illustrative stories in this manuscript due to space limitations, but the interested reader can find them in my dissertation (Pair, 2017). The framework and some of its corresponding characteristics will be discussed in the remainder of the paper. In that discussion, the list in Table 1 will be referred to as the NOM Framework, NOM being an acronym for the nature of mathematics.

Table 1

NOM Framework

Mathematics as a Fundamental Part of Human Cultures
<ul style="list-style-type: none"> • Western academic mathematics is one (but not the only) form of mathematics • Mathematical knowledge is influenced by cultural values. • Mathematical knowledge is embedded within the work of artisans. • The purpose of commercial-administrative mathematical knowledge is calculation for economic purposes; the efficiency and accuracy of mathematical procedures is valued.
The IDEA Framework for the Nature of Pure Mathematics
<ul style="list-style-type: none"> • Our mathematical ideas and practices are part of our <i>identity</i>. • Mathematical knowledge is <i>dynamic</i> and forever changing. • Pure mathematical inquiry is an <i>exploration</i> of ideas. • Mathematical ideas and knowledge are socially vetted through <i>argumentation</i>. <p style="text-align: center;"><i>Secondary Characteristics</i></p> <ul style="list-style-type: none"> • Proofs are bearers of mathematical knowledge. • Mathematics can be emotional and creative. • Informal mathematical work is foundational to formal knowledge. • Mathematicians change focus in a mathematical situation to achieve insight.
Statistical and Applied Mathematics
<ul style="list-style-type: none"> • Mathematical knowledge is used to shape society, but cannot be considered an absolute judge.

Discussion

The ensuing discussion connects the NOM Framework in Table 1 to both the MTE-Partnership (2014) principle highlighted at the beginning of this paper, as well as to Rochelle Gutiérrez's descriptions of humanizing mathematics (as suggested by a reviewer of this paper). Implications for secondary teacher education programs will also be incorporated. Note that the NOM Framework does not outline students' conceptions of the nature of mathematics, but rather forms a list of possible goals for students' understandings of the nature of mathematics that can guide instruction and research.

Mathematics is a Living and Evolving Human Endeavor

I set out to create NOM framework that was grounded in humanistic philosophy of mathematics. I wished to counteract the testing culture and the trend of viewing mathematics as an abstract value-free static body of knowledge. The MTE-Partnership (2014) indicator states that teacher candidates “are able to convey to their students that mathematics is a living and evolving human endeavor that relies on logic and creativity” (p. 3). Regarding the NOM Framework, we can see that mathematics is a living and evolving human endeavor in several areas. The first major category, mathematics as a fundamental part of human cultures, highlights the human aspect of mathematics in everyday life. The second category describes the discipline of pure mathematics; the evolving nature of mathematical knowledge is captured within the notion that mathematical knowledge is *dynamic* and forever changing. Gutiérrez (2012) also highlighted the importance for teachers to see mathematics as dynamic:

Unfortunately, many teachers are not aware of the uncertainty that is present in mathematics. Ask any person on the street to describe the nature of mathematics and you will hear words like “black and white,” “absolute,” “one right answer,” “truth,” leaving you with the idea that mathematics is static and predetermined. Yet, talk to a mathematician and you will learn that mathematics is constantly changing and does not always give one right answer. (p. 38)

Regarding mathematics teacher education, we need to consider ways to structure our programs so that future teachers begin to understand the dynamic nature of mathematical knowledge. Future secondary teachers should understand that new mathematical knowledge is being created every day and understand that their knowledge will be evolving throughout their lives.

Mathematics is Valuable for Its Intrinsic Interest

The MTE-Partnership (2014) document states that teachers need to help their students understand how mathematics can be pursued “for its intrinsic interest” (p. 3). During my own experience conducting mathematical research in this study, I found mathematics to be a very enjoyable exploration of ideas. After learning about this research, some of the students that participated in the study reacted with interest. But one pre-service secondary teacher said, “Why are you doing this? What is the point? I just want to teach high school algebra.” This student was not interested pursuing mathematics for its own sake. She believed that pursuing work on an unsolved mathematics problem was not relevant to her future career as a teacher. How can our secondary teachers inspire a love of mathematics learning in their students if they do not find value in pursuing mathematical ideas themselves?

The concept of joy while doing mathematics is central to Gutiérrez’s (2017a) vision of mathematics, which she calls *mathematx*.

Mathematx is a way of seeking, acknowledging, and creating patterns for the purpose of solving problems (e.g., survival) and experiencing joy. Beginning with the principles of recognizing self and/in others, responsibility towards others, and valuing tensions, several things stand out as different from the typical way Western mathematics is conducted or experienced by students in school. First, although some mathematicians experience pleasure as a result of solving previously unsolved problems, that aspect of joy is often a very small percentage of the time and almost always absent from the “mathematical product” (e.g., new theorem, new proof) that is valued by the community. Yet, mathematics education researchers who study aesthetics highlight this domain as essential to human meaning making and to the insights that mathematicians develop. (p. 15)

In addition to an emphasis on joy, the previous quote also highlights the personal and interdependent nature of mathematics. This again connects to the NOM framework and the notion that our mathematical ideas are part of our *identity*.

While I have pointed out some similarities between my work and Gutiérrez's work in humanizing mathematics, there are also some contrasts. Whereas my motivation was to develop a vision of mathematics that might restructure mathematics classrooms so that mathematics is not something we must suffer through, but something we can enjoy, Gutiérrez's conception challenges us to consider a world in which we change our fundamental human interactions to decolonize. As a white male educator, I may not always be aware of the way I am pushing the status quo. Gutiérrez recently argued that "mathematics operates as whiteness when we do not acknowledge the contributions of all cultures" (2017b, p. 8). The NOM framework that I have created may privilege Western pure mathematics too much, and not highlight the mathematics of other cultures (or living beings as Gutiérrez puts it) enough. My NOM framework does highlight mathematics as a fundamental aspect of human culture, and that Western mathematics is only one form of mathematics, yet a significant piece of the framework describes pure mathematics. Regarding pure mathematics, Gutiérrez (2017a) noted

When we use terms like pure mathematics or fundamental mathematics, we are 'othering' different forms of mathematics in ways that make them sound primitive or deviant. An Aboriginal stance would call into question whether any form of mathematics could be seen as pure, as it will always have a purpose and a grounding—cultural context—to start. (p. 16)

Gutiérrez's goal is to fight against colonization and find a way to do mathematics in a way that values interdependence and living beings learning from one another. She (2017b) writes,

I mean a program that takes seriously land, sovereignty, and the history of erasure of people through culture and language. I acknowledge the ways in which mathematics teaching and learning contributes to the denial of language and history for Indigenous students primarily. First, we must begin by acknowledging settler colonialism and ask whose history and whose language is part of mathematics? We cannot claim as our goal to decolonize mathematics for students who are Black, Latinx, and Aboriginal while also seeking to measure their "achievement" with the very tools that colonized them in the first place. (p. 12).

Gutiérrez challenges us to unlearn what we think we know about the nature of mathematics and consider alternative definitions of mathematics. For Gutiérrez, mathematics is the science of patterns, but the patterns she speaks of extend beyond those typically studied in a mathematics class (Gutiérrez, 2016). She suggests that we recognize that even trees notice patterns in their environment and are able to communicate in response to those patterns with new patterns, thereby benefitting neighbor trees of their own and different species (2017a). Indeed, she claims the plants and rocks are our ancestors, and we may be able to learn from them as they can learn from us. Or that we can learn from mathematics and mathematics can learn from humans. Then even further, we can imagine new patterns of interaction within our world and conceive of what actions would need to take place to bring about those patterns. In spite of these apparent differences, I believe both Gutiérrez and I have similar goals regarding peace for life on earth, and I will continue to reflect on how my work on the nature of mathematics connects with hers.

Conclusion

To say that students have naïve understandings of the nature of mathematics may be misguided. Their understandings of the nature of mathematics are a consequence of their experiences with mathematics. The nature of the mathematics that school students have experienced has a particular nature, and students may have accurate conceptions, descriptions, and beliefs about it. But with this study, I have aimed to discuss a different perspective of mathematics. In terms of teacher education programs, we must structure our learning environments so that future teachers come to see an alternative view. In order for school students to experience and view mathematics differently, it is a necessary but not sufficient condition that their teachers have had the opportunity to view mathematics differently. Teacher educators can play a role in bringing change about, by presenting future teachers with experiences that challenge their prior conceptions of mathematics and show them that a different mathematics is possible.

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Active Learning in a Number Sense Course for Future Mathematics Teachers

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Abstract

We report how the recommendations from the Conference Board of the Mathematical Sciences' *The Mathematical Education of Teachers* (2001) and *The Mathematical Education of Teachers II* (2012) have been implemented through a unique course. This Numbers and Operations-focused course, "Number Sense for Middle and High School Teachers," addresses among other things the concern that teachers be able to assist students in explaining the "why" behind the mathematics typically taught at the K–8 level. Furthermore, we discuss how we believe that using active learning strategies has impacted the future teachers who are students in this course. Finally, we discuss the impact on recruitment of students in a Noyce Track 1 Scholarship program. We believe that the course's focus on developing a deep understanding of topics provides the framework for future teachers to more fully understand many of the topics and underlying principles of mathematics taught at the secondary level as well. The active learning format of the course provides students an environment in which they can feel comfortable exploring subtly challenging mathematics and models good pedagogy for these future teachers. Students learn the mathematical practices that are related to problem solving, such as embracing failure and struggle, and valuing the process of discovery. Exposure to the type of sense-making content and active learning pedagogy in the course also seems to encourage students to be willing to be more involved in a Noyce Track 1 Scholarship program.

Keywords: Teacher preparation, number sense, conceptual understanding, active learning

Introduction

The University of Nebraska at Omaha (UNO) has collaborated with other universities engaged in the Mathematics Teacher Education Partnership (MTE-Partnership) to create institutional change in the way teachers learn mathematics at UNO. The Research Action Cluster (RAC) within the MTE-Partnership focused efforts on implementing active learning in the Precalculus through Calculus 2 (P2C2) courses. These efforts have influenced the adoption of such strategies in new courses at UNO, including a new course developed for middle school and secondary math teachers. The focus was on developing deep understandings of the topics frequently taught at the K–8 level with active engagement of students in a rich mathematics class. The course would provide students a new understanding of mathematical problem solving, use of definitions, and strategies that would result in strengthened preparation to be future mathematics teachers. The two main goals of the implementation were (1) to create deep understanding of many topics taught at the K–8 level along the connections to topics encountered in high school, and (2) to serve as an instructional model for future mathematics teachers in active learning. Finally, we will discuss a third benefit that is emerging from the implementation of active learning courses in the new course and others, that is, improved recruiting efforts into Noyce Track 1 Scholarship programs.

Mathematics Coursework for Future Teachers

To begin, an explanation of the first goal discussed previously will be provided. To do this properly, a detailed examination of the course rationale, development, and content will be provided, as the course itself is unusual. *The Mathematical Education of Teachers II* (MET II; 2012) recommended six semester hours in Numbers and Operation for future middle school teachers. Since many of states have primary endorsements to teach mathematics that is a combined middle/high school level certificate, the report implies that in these states all future teachers of mathematics should take these six semester hours. However, in 2014, Newton et al. reported that among 64 teacher preparation programs responding to a survey regarding course requirements, virtually none of them had a course on Numbers and Operations on the K–8 level. From this data, it is clear that the MET II recommendations have not been enacted on a comprehensive level. There are many other reasons why a 6–12 teacher would benefit from exposure to such content. Since many middle school students and high school students struggle with material and concepts developed from lower grades, their teachers frequently teach courses that are cover topics from earlier years. Moreover, future 6–12 teachers can benefit from a stronger foundation in Numbers and Operations because of the carryover effect in their understanding of related topics in algebra and more traditional high school content.

The UNO Course Content

The Number Sense course developed at UNO is an exception to the trend nationally to not include a course on numbers and operation. The course is required for the secondary and middle school math education endorsements. The course uses the textbook *Mathematics for Elementary Teachers with Activities* by Sybilla Beckmann, which despite the title, covers K–8 content (Beckmann, 2014). For this course, topics that were identified as seventh- and eighth-grade topics and not normally covered in the elementary version of the course, such as proportional reasoning, were included. Topics that are firmly in the K–6 curriculum but are known to be those that students struggle with in future years, such as fractions, were included. Students in the class tackle the tasks of “why” certain algorithms work the way they do, how to represent different mathematical ideas, and various ways to justify their conclusions. Students also encounter problems solved with multiple strategies, as opposed to believing there is only one way to solve a given problem. They develop mathematical habits of mind that are a basis to good problem-solving skills (Sword et al., 2018).

Modeling Effective Teaching Practices

A second goal of this course and this paper is related to the course instruction serving as an instructional model for future mathematics teachers in active learning. The integration of pedagogy and content in courses designed for future mathematics teachers has been identified as an important part of a quality teacher preparation program as identified by the National Mathematics Advisory Panel (2008) and the National Research Council (2010). Dating back to 2003, Ferrini-Mundy and Graham noted that over the years questions have been raised, not just about the nature and extent of the mathematics courses required by teacher education programs, but also about the integration of mathematics and pedagogy.

Attention to pedagogy used in mathematics content courses is imperative. It is often said that “teachers teach as they were taught” (Hall et al., 2006). Current research reveals that teachers actually teach in the way they preferred to be taught, or the way they believe their students will learn best (Cox, 2014). Teachers are more likely to integrate high-quality mathematical practices of teaching (Cobb et al., 2011), when they have productive experiences modeling such practices first as students in a college classroom. The integration of active learning principles in a Number Sense course will expose students to this form of instruction.

Extending Active Learning into Content Courses for Teachers

The use of active learning at UNO can best be described by the concept of inquiry-based learning (IBL). IBL, according to the Academy of Inquiry Based Learning (2018), is a learner-centered method that deeply engages

students and in which students collaborate on their learning in some fashion. In the UNO course, students do more than take notes and write down definitions. Rather, they tackle tasks that require them to engage with one another, experiment, and communicate their mathematical ideas to one another. Students are encouraged to embrace the attitude in which failure and struggle is not stigmatized, but rather, the process of discovery is encouraged, and thus they learn to value perseverance more and develop a growth mindset. The role of the instructor is to guide the students in their sense-making. IBL promotes the mathematical practices called for by a variety of organizations and in the Common Core standards (see Common Core State Standards Initiative, 2010; National Council of Teachers of Mathematics (NCTM), 2012a; NCTM, 2012b).

The UNO Class Educational Philosophy and use of IBL

Several years ago, the authors went through significant training in the use of IBL in the classroom. As part of the RAC initiatives, some Calculus and Precalculus classes – required classes for future teachers – have integrated IBL into the instruction at UNO during the past five years. The impact of IBL instruction on students has been mostly positive, and the decision was made to utilize active learning in other required courses for future teachers. IBL was utilized in teaching a History of Mathematics class, which was required of all secondary math majors (Matthews & Hodge, 2016). An active learning class in number sense appeared to be a sensible next step in providing a good preparation for mathematics teachers and so IBL was intentionally implemented into the course structure.

In the class, students are inundated with opportunities to develop mathematical habits of mind and to communicate mathematical reasoning. The active learning format of the course provides students an environment in which they can feel comfortable exploring topics in K–8 mathematics from an advanced perspective that pushes even the strongest students to pay attention to precision, definitions, and reasoning. The ultimate goal was a well-crafted solution through an adventure in mathematical discovery (Kogan & Laursen, 2014).

The use of IBL and active learning in the Number Sense course helps model the mathematical practices called for in various national standards, providing students an opportunity to be inspired to become teachers that utilize active learning in their own classrooms. The premise is that students who are thus inspired are more likely to engage their students in active learning in future classrooms.

The Classroom Environment/Typical Day Structure

Changes to the physical environment facilitated active learning. Traditional desks were replaced by tables and chairs. The arrangement encouraged students to focus their attention on one another and on their personal exchanges, rather than on “the sage on the stage.” Students were initially in self-selected groups, but some instructors switched groups throughout the semester.

As class begins, table groups determine if any significant questions remain from the select homework problems. These homework problems were chosen because they had important concepts embedded within the problem. After the class agreed on two or three problems to be discussed as a group, students volunteered to present their solutions to the class. Often a student would say, “I’m not sure if I have it right, but I’ll put up what I have.” This example is a great testimony to the strong support students give to one another and their willingness to work cooperatively. Often, more is learned from the presentations with errors than those that are correct. It was frequently frustrating to students as they struggled with topics that they considered quite basic, such as fraction operations and problems related to properties of arithmetic. As the students presented their work and provided detailed explanations, the teacher of the class felt that students developed deeper understandings of the topics. Most students believed they “knew how to do the math,” but learned they didn’t necessarily understand the “why” behind the strategies and procedures used in K-8 topics before the class.

After an initial introduction of the day’s topic and student presentations on homework, students are provided guided activities to complete at their tables. Typically, the brief presentation (5 minutes) simply allows

the instructor to set the stage for the activities and the concepts for the day. The activities were those that accompanied the text, which was designed for future elementary teachers. Hands-on manipulatives are frequently used in the course, which is typically the first experience these students have had with using manipulatives in a math content course. While students are working together on activities, the instructor circulates around the room listening to students and their exchanges and gives gentle nudges when needed, rather than simply providing an answer. If a common question surfaces around the room, or there is a major point of confusion among several of the students, the groups may report out their work, and they may all work jointly to develop a solution. An active-learning classroom is one in which students feel comfortable failing, evaluating, and trying again (Miller-Reilly, 2007). An attitude of resilience and persistence in solving problems is the goal.

Students also would lead discussions of the topic at hand from the activities. During the activities, presenting a problem meant that a student would put his or her work up on the board after the class had sufficient time to work through the problem within their group. As time allowed the student who presented would explain the work.

Participation Grading

The active participation grade was a key element in what made the Number Sense course different from traditional mathematics classes. It was decided that students would be required to present several times before the end of the semester as part of their participation grade. The participation grade was more than just presentations. Students were expected to attend class regularly and attend at least two out-of-class mathematics activities. Activities have included helping grade problems in the High School Math contest, attending Cool Math Talks, and participating in UNO Math club events. These activities and events were selected to provide opportunities for future teachers to engage with others in rich mathematics and to take part in outreach activities within the mathematics education community at UNO.

Student Reactions to the Number Sense Course/Active Learning structure

The following are actual student comments after completing the Number Sense course, which helps to illustrate the impact on students. The results demonstrate how student beliefs about teaching and learning mathematics can change by taking even one course that employs the active learning method of teaching and focuses on the deep understanding of K–8 level mathematics.

This course was one of the hardest but most rewarding math classes I've ever taken. I know for me, having graduated in the late '90s, math was 80% procedure and 10% concepts. Needless to say, I always hated the two story problems at the end of the homework. Going into the semester, I had wanted to develop my understanding of math concepts. Math was something I always did well in when it came to procedures, but I needed to develop my math sense - to understand the why behind the what. I feel this class did that. I can see math in different ways that I never could before. Even my simple math sense such as adding quickly has improved. It's not to say this class wasn't at times frustrating. It was. I had to go back to the foundations of what I had learned decades ago to fill in the missing pieces. The hardest thing for me outside of the content was having to write specifically without seeing an example of it. Most everything was well explained verbally and in multiple ways, but I could have benefited greatly from those explanations being written down.

All this to say, I think this class is necessary for teachers. Knowing how to do math and teaching math are two very different things. This class helps teachers deepen their understanding of conceptual mathematics. I think I will be a better math teacher because I took this class.

Recruiting Future Teachers into the Noyce Math Scholarship Program

Before concluding, a look at the third point is given, which is perhaps of great interest with the expansion of Noyce scholarship programs nationally. Like many Track 1 Noyce programs, recruiting future teachers to get degrees in mathematics and to commit to teaching in high-need schools are two of the biggest issues. As students have been engaged in active learning classes, such as the Number Sense course, they seem to be more likely to apply for the Track 1 Noyce Scholarship program than those in traditional classes. This mimics what has happened in Calculus and Precalculus classes at UNO (Rech, Hodge, & Matthews, 2017). Every day, instructors get to hear students think and watch them work collaboratively with other students. Students are interacting and helping others in the classroom.

Faculty frequently encourage promising students to take part in a Noyce scholarship program as scholars and interns. Students who would significantly contribute to the Noyce program and potentially make future teacher leaders are identified. They are invited to: (a) apply to be a Noyce summer intern (an internship in teaching), (b) visit with our advisor to take more mathematics courses, (c) work with faculty on mathematics education research and other projects, and/or (d) work as learning assistants in mathematics courses.

The recruitment is a result of the efforts tied to the Actively Learning Mathematics RAC within the MTE-Partnership. A goal was to institutionalize active learning into the calculus sequence and use these teaching techniques as recruiting tools for future mathematics teachers. Although the institutional level of implementation has not been reached, the successes of using active learning in calculus with students and future teachers led to the expansion of using active learning to the Number Sense and History of Math classes. Promising teachers and future teacher leaders have become accustomed to and thrived while learning in an IBL format. They may be heavily influenced toward engaged and active teaching in future classes because of multiple IBL and active-learning experiences.

Future Plans and Conclusions

The Number Sense course appears to provide an opportunity for students to see many topics in mathematics from a new perspective. The students often reflect that it was “the most useful” math course they took as an undergraduate student and truly opened their eyes to what “deep understandings” in mathematics means. Future efforts could focus on how learning in this class affects their ability to understand mathematical concepts that are only taught in high school. Many of the students in active-learning classrooms have grown to think that active learning, which aligns with the mathematical practices of teaching, is an effective way to learn mathematics. Since we are asking our teachers to instruct this way in the classroom, we value this outcome. If Cox (2014) is correct, this leads us to believe that the future teachers in these active learning classrooms will also teach mathematics in an active manner. As a result, they will be better prepared to teach their students by directly incorporating the mathematical practices of teaching. Future efforts could study to what degree teachers who have significant active learning strategies modeled in their undergraduate curriculum use similar strategies in their own teaching.

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PRESENTATION ABSTRACTS

Adaptations and Transformations for Recruitment and Retention of Secondary Mathematics Education Majors

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This presentation will share findings from approaches involving adaptations and transformations for recruiting and retaining diverse students in a secondary mathematics education program at a southeastern university. In recent years, changes in university-wide and state policies and procedures have influenced overall approaches for recruitment, retention, and graduation of students in ways that precipitate the need to plan, adapt, or transform approaches for recruiting and seeking retention of students in mathematics education. The use of Plan-Do-Study-Act will be discussed regarding approaches to recruitment and retention of students majoring in secondary mathematics education, along with ways of gathering data, the analysis of the gathered data, and results in the decision process. Results of approaches that have been more and less successful will be shared and discussed. Findings can help inform and transform recruitment and advising efforts that are currently happening in programs across MTE-Partnership institutions. Participants will have an opportunity to consider and discuss activities and avenues at their institutions for pursuing and supporting approaches for recruitment and retention of diverse individuals into secondary mathematics education programs.

An Emerging Framework for Understanding the Development of Mathematical Knowledge for Teaching

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Improving the preparation of mathematics teachers is a “wicked problem” (Gomez, Russell, Bryk, LeMahieu, & Mejia, 2016, p. 10) requiring the participation of all stakeholders. One component of mathematics teacher preparation, attending to mathematical content knowledge and knowledge needed to teach mathematics (MKT), is complex and impacted by both mathematicians and mathematics educators. The MODULE(S²) RAC aims to improve the mathematical preparation of teachers through the creation of curriculum materials for use in upper-level content courses for secondary mathematics teachers. With the goal of developing MKT within content courses through the use of simulations of practice, it becomes essential to have a working model for the development of MKT so that mathematics educators and mathematicians provide feedback on the work of prospective teachers. We will present an emerging framework that leverages the research on educative curricula and serves as a resource for writing, refining, and implementing educative curricula for teacher preparation. We base this framework in existing literature on MKT: Silverman and Thompson’s (2008) framework for the development of MKT which proposes MKT as a consequence of decentering; Rowland and colleagues’ Knowledge Quartet for dimensions of observable teaching-actions using MKT; and Ader and Carlson’s (2018) framework for analyzing and observing decentering. We will describe how this framework aids in the creation of simulations of practice for use in developing MKT and then illustrate its effectiveness for understanding developing MKT through analysis of data gathered during pilots of curriculum materials.

Addressing Social Justice and Equity in the Statistical Education of Teachers through Statistics Activities

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We present the work of the MODULE(S²) RAC's statistics team who have developed statistics activities that engage pre-service teachers in analyzing data relevant to social justice and equity issues. The activities include data from general societal issues and education-specific issues. Examples include racial gaps in job search success and unemployment, the relationship between school district poverty and test scores, and car insurance pricing trends related to minority percent in various Zip codes (adjusted for claim rates). We take care to discuss the pitfalls of a deficit-based view of these issues. These activities provide a model as to how secondary teachers can address issues of equity and social justice in their math classrooms. We are teaching mathematics teachers to enact equitable pedagogies that foster critical thinking and teach students to be active participants in democracy. We are doing this by using data sets and analysis methods that an active, critically-thinking citizen could use.

Reflections from Noyce Scholars on their Route to STEM Teaching

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When the supply of well-trained professionals does not meet demand, stakeholders oftentimes focus on incentive programs to increase supply. The federal government has a few initiatives that incentivize college students to become teachers. One of the most well-known scholarship programs for perspective mathematics and science teachers is the Robert Noyce Teacher Scholarship Program. This scholarship program encourages talented STEM students to pursue teaching careers in mathematics and science by providing institutions of higher education funding to recruit individuals with strong STEM backgrounds who might otherwise not have considered a career in K–12 teaching. Using scholarships as a mechanism for recruitment and retention of teachers in high-need fields requires further research. Thus, the researchers at Texas A&M University designed a three-year, longitudinal, quasi-experimental, mixed-methods study to help determine the perceived effects, influences, and impacts the Noyce scholarship on its recipients. Across the three years of the study both quantitative and qualitative data were collected via surveys and interviews from 29 participants. The surveys were distributed to the participants each June from 2015 to 2017 and had a mix of ordinal, categorical, and open-ended questions. Results indicate that even though the Noyce Scholarship did not influence the scholars to choose teaching as a profession, or to teach in high-need schools, it has contributed to their persistence in high-need schools for the length of their obligation and in other personal, financial, and professional ways.

Cooperating Teachers' and Teacher Candidates' Dual Engagement Modules During Methods Course(s)

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This session will provide an update and report on three modules the Clinical Experiences sub-RAC of Methods has developed and is working on. The report will provide the results from the first module ready for full implementation last year, and the progress and reports on the second and third modules. Module 1 focuses on the Mathematical Practice standards, Module 2 on lesson planning around the MCOP², and Module 3 on providing rich student feedback related to mathematical goals. Each module involves components of teacher candidates in methods courses, then integrating their cooperating teacher briefly into the module work to setup a collaborative environment well before entering the internship in a subsequent semester.

Using a Common Observation Tool to Better Align Teacher Preparation and District Partner Professional Development

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This session will share the successes and challenges that have resulted from using the Mathematics Classroom Observation Protocol for Practices (MCOP²) to focus our engagement with university teacher educators and school district partners to develop, discuss, and refine a shared vision of student engagement in the 21st century mathematics classroom. This work has involved faculty from elementary education, secondary education, special education, and mathematics, as well as administrators and teachers from three school district partners. Impacts include changes to mathematics methods coursework within three credential programs, a more explicit focus on student engagement during observations of teacher candidates, and increased conversations among mentor teachers about ways to change lesson design and instructional practices to improve student engagement as viewed through the lens of the MCOP². During the session we will ask participants to (a) participate in a portion of the MCOP² training we have developed, (b) examine and reflect on data generated from the use of the MCOP² among teacher candidates, and (c) hear from school district partners about their use of the MCOP² to support and extend ongoing efforts to shift instructional practices in mathematics.

Examining Prospective Mathematics Teachers' Reactions to Definitions of Diversity, Equity, and Social Justice

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As mathematics teacher educators one of our responsibilities is to support our prospective teachers in understanding equity, diversity, and social justice. To develop such an understanding, we must define these complex terms for ourselves and think about the purpose and usefulness of these definitions. In this session, we will discuss the definitions developed by the Equity and Social Justice Working Group and how 18 prospective teachers reacted to these definitions, focusing on issues that they found problematic and parts that they found useful. During their student teaching seminar this group of prospective teachers has been reading about and critically assessing their own beliefs about equity and social justice in mathematics classrooms. The feedback that they provided was after spending time in class developing their own understanding of these terms. Discussion will center on their reactions to the definitions and how we might talk with our prospective teachers about equity, diversity, and social justice.

Paired-Placement Internships: A Collaborative and Empowering Model for Clinical Teaching

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The paired placement model for clinical teaching places two teacher candidates with one mentor teacher. This model has been dubbed as a model of learning to teach that encourages collaboration, pedagogical risk taking, increased reflection, and better classroom management. Members of the MTE-Partnership's paired placement sub-RAC have implemented the paired placement model across multiple institutions for three years and have used Plan-Do-Study-Act (PDSA) cycles to collect data before, during, and after the clinical teaching experience. The PDSA cycles incorporate interviews, surveys, teaching evaluations, and reflective journals. At the end of the clinical teaching experience, a final PDSA cycle is conducted via a web conference meeting whereby participants share their experience and engage in an informal discussion about their clinical teaching experience. The participants in the study were secondary mathematics teacher candidates who were enrolled in university-based teacher preparation programs. Participants at each university were selected differently; some universities only had two secondary mathematics teacher candidates and as such, the two candidates were selected as participants. Other universities had a larger pool of candidates and either hand-selected the participants or took candidates who volunteered to be a part of the study. In this presentation, members from the paired placement sub-RAC will share the work they have done and present results from the PDSA cycles that address the successes and challenges of implementation of the paired-placement model at each of the different universities.

Undergraduate Learning Assistants in Mathematics: Designing Opportunities to Recruit and Prepare Future Teachers

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The undergraduate learning assistant (ULA) program has been used in science and mathematics departments to support course transformation in large-enrollment introductory courses. ULAs in mathematics, while more often used to support active learning models in the Precalculus through Calculus 2 (P2C2) sequence, are also excellent potential recruits for secondary mathematics teaching. Their early field experiences in undergraduate settings offers a unique opportunity for potential candidates to explore ways to support student problem-solving, persistence, and reasoning in the context of a recently familiar experience. This paper presents a synthesis of research findings, along with recommendations for how ULA programs can be designed to address multiple goals relevant to the MTE-Partnership: recruitment of secondary mathematics teachers, development of math knowledge for teaching, and support of active learning models in the calculus sequence. Through the articulation of specific goals, and collaborative action between faculty responsible for teaching courses in the P2C2 sequence and mathematics educators responsible for secondary math licensure, the ULA model can be (re)designed to address multiple synergistic outcomes.

Find Ways to Talk: How Interns and Mentors are Using Co-Planning Strategies

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In this session we will share results of a study in which we examined interns' reported use of the six co-planning strategies proposed by Cayton, Grady, Preston, and Sinicrope (2017) and interns' and mentors' reports about which strategies they felt most comfortable using. This research provides us with insights about the perceived usefulness of the different strategies in an internship setting. Results show that specific strategies were used more often than others, and there appears to be a correlation between strategies that interns and mentors felt most comfortable with and the reported use of strategies by interns. However, there are some inconsistencies between reports of interns and of their mentors regarding use of and comfort level with the strategies. These inconsistencies provide ideas about how we might need to improve training and suggest some interesting avenues for future research. During this session, we will share data from interns' and mentors' post-internship surveys and from the weekly journals of 11 high school mathematics interns. There will be a time for discussion about future research and for participants to share their own experiences using the co-planning strategies.

Does Co-Teaching Make a Difference?

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This session will examine the difference in teacher candidates' responses to questions about preparation between California State University (CSU) schools that use a co-teaching model and those that do not. CSU is the largest producer of mathematics teachers in California and prepares nearly 8% of the nation's teachers. All pre-service students in the CSU system are asked to fill out a completer survey at the end of their credential program. The completer survey captures candidates' perceptions of preparation and their confidence in their ability to teach. There are sections specific to teaching mathematics and include questions related to how well they were prepared to support students in the Common Core Standards of Mathematical Practice, develop students' conceptual understanding of content, and use effective strategies. Of the 22 CSU campuses with teacher preparation programs, 11 use co-teaching as a clinical model for secondary mathematics pre-service candidates. This session will provide valuable insight regarding the effectiveness of co-teaching as a clinical model from the perception of the student teacher.

Practices that Support Beginning Mathematics Teachers

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The landscape of teaching as a lifelong career seems to be changing. In previous decades, teaching was viewed as a lifetime profession, but this viewpoint is transforming. Now, it is not uncommon for teachers to enter the profession with the mindset of staying for a few years until other, sometimes more profitable, opportunities arise. Other teachers enter the profession with a career mindset, but circumstances change their perceptions, and they leave the profession with no intent to return. Better understanding the factors that influence teachers to leave or stay in the profession is an objective of the STRIDES RAC. This RAC's primary work focuses on studying aspects that influence teacher retention and then translating this work to improve teacher retention among MTE-Partnership programs. As part of their early work, the STRIDES RAC developed a survey for pre-service, first-, second-, and third-year secondary mathematics teachers. The goal of the RAC is to use the data from the survey to better understand how, and by whom, early-career mathematics teachers are supported. The survey was distributed in December 2016, and again in December 2017, by various MTE-Partnership partners. One of the MTE-Partnership partners, Texas A&M University, had 25 unique respondents for the 2016 survey, 45 unique respondents for the 2017 survey, and six unique respondents who completed the survey both years. In this session, the analysis of and implications from the data produced by these respondents will be shared and discussed.

CLOSING REMARKS

MTE-Partnership Reflections from an AMTE Lens: Reacting and Catalyzing

Michael Steele, University of Wisconsin-Milwaukee, steelem@uwm.edu

When I was invited to the MTE-Partnership meeting, it was with the purpose of serving as a reactant: to observe and interact with partnership groups and research action clusters (RACs) as they worked, and to provide some remarks at the close from an AMTE perspective to continue to push the thinking. Borrowing from a conversation with my co-reactant Cathy Martin, I think that the metaphor of “reactant” is a bit fraught – I don’t wish to invoke the notion of a caustic chemical reaction that wouldn’t take place if not for my presence. Rather, I’d like to invoke the notion of a catalyst, in the hopes that my perspectives shared here will help shape and change the work of the MTE-Partnership in some small way.

First and foremost, I’d like to thank everyone for letting me wander in and out of the RAC sessions and make obnoxious comments as you were doing your work, letting me be annoying, pushing on some things and then scurrying out the door. I also want to thank everybody for taking seriously the work of integrating the AMTE Standards for Preparing Teachers of Mathematics. As the person who led the AMTE task force charged with disseminating the Standards and now as President-elect of AMTE, I’ve always maintained the stance that we must work to bring the Standards to life if we wish them to have a meaningful impact on the work of teacher preparation. They have the potential to be just another document on a shelf, either a physical or a virtual one, and I think there’s probably a dozen documents that I have that are like this. It gets released, it’s interesting, we read it, and they sit on a shelf and collect dust because there’s never any effort to bring them to life. I want to thank you all for bringing the standards into the work, into the MTE-Partnership, and into the RACs; specifically because it’s going to be what helps bring these Standards to life and makes them operational. With that, I want to say a few things about why the MTE-Partnership matters from an external view, with the goals and aims of AMTE in mind.

The MTE-Partnership’s focus on secondary mathematics teacher preparation is critical. Too much of what we do in secondary mathematics teacher preparation has been idiosyncratic and local, and that’s largely because we’re smaller in numbers compared to elementary. Where I see the MTE-Partnership contributing significantly to bringing what I am referring to as *sensible data driven homogeneity* to the work of preparing secondary math teachers. This is not to say that we should or have to make every program look the same, because we don’t, and we shouldn’t. There are, however, some aspects of preparing secondary mathematics teachers that should be a central core to the work that we do across programs and institutions. A strength I see in the work of the MTE-Partnership is a networked community bringing forth deep and meaningful conversations about the work we do in preparing secondary math teachers. Across the RACs that I sat in on, I was pleased to see a focus on data collection and research across sites and across contexts.

The AMTE Standards provide guidance for programs at both the individual-candidate level and at the program level. For candidates, this means thinking about their mathematical knowledge for teaching, their dispositions, why they’re staying in programs, and why they’re leaving programs. For programs, this means thinking about program-level transformation, which is critical, as I believe that as a field, we have not thought about program transformation as systematically as we could. Pulling first on the candidate knowledge, skills, and dispositions from the AMTE Standards, I could walk around to every one of the RAC meetings, every one of the

presentations, and see aspects of all four of the ideas in the candidate standards coming forth in the work that you do. The candidate standards are center mass of the work that you're doing.

Now I'd like to provide a few things to consider with respect to the Partnership's embracing of the AMTE Standards and the implications of that work. I wonder to what extent the MTE-Partnership work is embodying a shared set of values. You may think, "Well, of course there are a shared set of values. We have a mission and goals, and the driver diagram," and I would agree. My push for you to think about is, how is the work that you're producing embodying those values and making them visible? Could I walk through and see those reflected in everybody's work? And I think that the question that we grappled with Monday afternoon, and that the MTE-Partnership will continue to grapple with, is how are the cross-cutting working groups focused on equity and transformation of programs providing coherence for the RAC work?

Also, how are aspects of the shared vision made visible in the work you're producing? For this, I go to the assumptions that are listed in the AMTE Standards. The idea behind these assumptions was that there exists a core set of values and a shared vision that we wanted to be embedded in everything that mathematics teacher educators do, in the name of advancing the candidate standards and advancing the program standards. These assumptions are not necessarily the MTE-Partnership's shared values exactly, but I think an articulation of the MTE-Partnership's shared values are embedded in these assumptions. For example, the assumptions note a focus on equity and career-long learning. The STRIDES RAC group is thinking about how to launch career-long learning with a central focus on mathematics. The ALM RAC has a strong focus on the idea of learning to teach mathematics involving mathematics content, which is another one of the assumptions. Having multiple stakeholders invested in preparing teachers of mathematics, another assumption, seems fundamental even just to the formation of the MTE-Partnership. Finally, being committed to improving the effectiveness of mathematics teacher preparation programs connects to the fundamental character of the MTE-Partnership as a networked improvement community.

The AMTE standards also identify program standards, which discuss the importance of partnerships, opportunities to learn mathematics, to learn to teach mathematics, and recruitment and retention. Attending to program features and standards is work that the MTE-Partnership institutions are focusing on, trying to figure out how to do good work in secondary mathematics teacher preparation. The notion of assessing these program standards is an opportunity in which the MTE-Partnership has to be a leader in the field. Consider the question, what would the data be that would show that programs are meeting the set of program standards well?

As I noted, I have a few gentle nudges from the AMTE perspective that are designed to help MTE-Partnership teams, individually and collectively, think about how to advance the work that you are doing and support the field of mathematics education. Let me start gentle nudge number one with what might be a controversial statement: It's becoming increasingly clear that the halcyon days of having multiple robust mathematics teacher preparation programs at multiple universities in every state are all but over. I look at my state of Wisconsin, and we have mathematics teacher preparation programs at the University of Wisconsin-Milwaukee, Madison, and LaCrosse; Marquette University in Milwaukee; Alverno College; and at least a dozen more private and public institutions across the state. A decade ago, we would view these programs as competition. Now, we are thinking about them as places in which we can share and pool resources, because in some sense it's the only way our programs are going to survive, let alone thrive. I know this is not a phenomenon unique to Wisconsin. Here is how I think the MTE-Partnership can make a productive contribution to this issue: How can you translate the idea of the networked improvement community upon which the MTE-Partnership is built to the local or regional context? Nebraska is a leader in this thinking with respect to how they are pooling resources across state institutions and then branching into the private sphere. I think this is a direction we as a field will need to take if we are to take seriously the charge of innovating, growing, and advocating for the work of mathematics

teacher preparation. The questions to this group are: What aspects of what the larger community does can be translated and adapted to the local context, and how can the work at the local level be shared back into the larger network to improve the broader community?

Gentle nudge two is about how this group can advocate for coherence in secondary mathematics teacher preparation. I wrote this down as I was listening to one of the MODULE(S²) talks yesterday. The speaker said, “Every institution is different related to lesson planning format.” I immediately heard that and said in my mind, “Yeah, they are,” and then I immediately had a second reaction to it: “Why? Should we be?” Aren’t there some things that we agree that we care about in lesson planning? This disconnect feels like 20 years ago when I was a middle school classroom teacher and it was OK to teach differently from down the hall because teaching is just a matter of style—and that’s Ray’s style down there and that’s Mike’s style over here, and they both work fine. All of our research tells us that is not the case. So why are we accepting this in our own community? I want to think about: How can the MTE-Partnership advocate for and promote some common structures, routines, and tools in preparing teachers of mathematics. How do we identify what are the things that we know work? What are the things that we know are effective? I think about the *Principles to Actions*’ effective mathematics teaching practices that are transforming, catalyzing my own work in preparing teachers. Is there an analogous list of effective mathematics teacher education practices that we should be naming, identifying, and doing across our contexts?

For gentle nudge number three, I’m going to pick on Wendy Smith, whom I heard yesterday saying, “Having meetings can be progress,” and today said, “Stop reinventing wheels.” I heard every RAC talking about the data you’re going to collect, how to document what you’ve done, and as academics, these conversations start small, and they expand exponentially quickly. All right, we’re going to collect data on these three things. So, thing two really needs to have seven sub-bullets to it, and we should think about thing four, and five... and by the time we’re done we now have a list of 371 items about which we’re trying to collect data. Now that you have a history of designing tools, making decisions, and creating resources, I want the MTE-Partnership, and the RACs in particular, to think about: What are the non-negotiables in the data you want back about these ideas? There could be 100 different ideas about data you’d like back about idea A that could be helpful with Idea B, but really what are the core non-negotiables, and then how are revisions going to be made public to this community and then disseminated outside this community? I think with an edited book on the horizon, this task is going to be an important one to make that work useful to the broader community. I’d encourage you all to keep writing and making the tools that are successful public. You don’t have to open everything up and share every single thing that you’ve done. But think about, what are the real successes that you want to highlight out of this work and bring those forward to the community.

Thinking forward to my term as president of AMTE, which starts in February, and a couple of the priorities that we’ve already talked about as a board, I intend to move forward a more public national push toward recruitment and retention, reshaping the conversation about what mathematics teaching looks like in conjunction with NCTM and several of our other partner organizations. I can imagine this work connecting to the work that the MTE-Partnership, and PR² in particular, is doing and elevating that work. There’s been talk within AMTE about, if it would make sense to collect a set of secondary mathematics methods resources and create a book or resource that can be used as a secondary mathematics methods text? These are all things on the horizon that you’re thinking about as a community. I want to encourage you to consider AMTE as a partner in doing that work, and I want to thank everybody for the very interesting conversations about what my goals are for AMTE and finding these points of connection with the MTE-Partnership. Think about what the boundaries of the MTE-Partnership should be. Where are they now? Where should they be? What ideas move across those boundaries, both out into our general community and down in to your local regional networked communities? The MTE-Partnership is an incredibly productive, highly functional, and well-managed group. Thinking about where things move from here is

important. AMTE has already put out a call last fall for supplementary materials related to the Standards, and there's going to be a refresh of that call coming out and one related to program standards. These are resources that we would like to give to our broader AMTE community that represent these sorts of best practices. Please consider submitting, when you see that call come out, some of the artifacts that you've designed and embedded; they don't have to be large, we're thinking small here. Small pieces that add up to something larger. I want to thank the MTE-Partnership once again for having me, and being able to provide some thoughts from the AMTE perspective.

Realities and Opportunities in Public School Settings

Cathy Martin, Denver Public Schools

I grew up in Texas, and I moved to Colorado in 1989. To put some context to the K–12 system, I want to tell you a little bit about different types of schools. I am now the executive director of curriculum and instruction for Denver Public Schools, and I was the math director for 13 years. We have 207 schools in Denver, and they're both charter and district managed. So when you think about the teachers that you're preparing to come into our schools that could be for charters, district managed, private schools, or rural schools.

With more than 92,000 students, we have a very diverse population. We have more than 140 languages spoken in Denver Public Schools. The majority of our students are Latino, followed by white/Caucasian, and then African Americans, and smaller numbers of Asian and American Indians. Our schools are an average of 67 percent free and reduced lunch. Our teachers teach in schools with poverty, and we have several of what we call "newcomer centers," for students from other countries. Thirty-seven percent of our students are bilingual learners, and the primary language spoken is Spanish.

While I'm telling you about Denver, this could be any urban district in the United States; this is not unique to Denver. Our state test is CMAS, and CMAS math for Grades 3–5 on average across the district is 32 percent to 40 percent proficient. Moving up to Grades 6–8, it's 20 percent to 30 percent proficient. There's a problem at middle school. At high school, our state test is the PSAT/SAT. It will be the first year this year that ninth-graders took the PSAT 8/9, and for 10th grade, about 34 percent meet the benchmark for the PSAT. For SAT at the 11th grade 34 percent hit the college benchmark. Therefore, you can see we have a lot of work to do in Denver, and we have many opportunities for growth. One opportunity is that we have significant gaps between student groups at all grade levels, and, if you're familiar with Colorado graduation requirements, you know that in 2021 our students graduating high school will have to demonstrate competency in mathematics and literacy in order to graduate—for the first time ever. Now, there's a whole menu of competencies from PSAT, SAT, ACT, the ASVAB, or you can score a certain level on the AP test, and so you get the picture that there are lots of different ways folks can graduate.

Denver has set some ambitious goals, as I'm sure all school districts have done, and we've also set what we call instructional priorities. As Mike Steele was saying, instead of doing all these 371 things or collecting all of this data, what we're trying to do is to focus on what we see as four areas for instructional improvement. The first one is early literacy, which should be no surprise to you. But this is really about having kids on track in reading and writing at third grade, which then the trajectory from there through high school is really strong. The second one is culturally responsive education. We have talked a lot about equity and social justice, but we're also talking about the cultural responsive aspect so that we honor kids' cultures—their cultures, their families' cultures, their backgrounds. Another one is coaching and leadership in service of "best first instruction." The interesting thing about that is we have yet to define best first instruction. We're all about coaching and leadership, so we need to think about how to support our school leaders, whether that's principals, assistant principals, deans, teacher leaders, in really being to be able to coach and lead for best first instruction. The last one is college and career readiness. I'm happy to say our work this year on college and career readiness includes a focus on secondary mathematics.

Another area of opportunity for DPS is around recruiting, developing, and retaining teachers for every DPS school with incentives and supports for teaching in our highest-need schools. We have a real need at middle school, you heard the data for our middle schools, that's our lowest achievement data that we have. We have a really difficult time finding middle school teachers who are qualified in mathematics. At the same time, we're redesigning the high school experience, and part of that is, for the first time ever, we have a mathematics strategic plan that's getting district-wide attention. We've had strategic plans before, but none could get the leverage that we needed. Let me add also that oftentimes we'll hire teachers and they'll be gone in two or three months, so the STRIDES group, which is working on thinking about how you support teachers in their first few years, is really important because in urban schools we often see them leave quickly.

Another thing that should be on your horizon as you think about preparing teachers is that we're focused on meeting the needs of all students but doing it by thinking about three pathways in high school. The first one is the early college schools, where students will earn credit, college credit, in high school, through concurrent enrollment classes. They have to score at a certain level on the Accuplacer so that takes a certain bent on what we need to study in mathematics to prepare for the Accuplacer placement test. The second one is what I call our comprehensive high schools, those that look at preparing kids for college more so than careers and using the PSAT and SAT as a real driver in that. Third we have our pathway schools for students who are over age and under credit. We need to accelerate their attainment of credits as quickly as possible and that's done through a quarter system or a trimester system, which has definite disadvantages in terms of the time the kids have.

So, here are our realities. Here is what you are up against in preparing students to come into K–12 education. One is this intensive focus on testing. I was in one session and talking about administrators who were very concerned about testing—as well they should be—because their schools are evaluated by those student results. I would say to you that your challenge is to think about how you can help your prospective teachers and the school leaders that you work with to think about smart test preparation. How you do it in a way that embeds it in the instruction. Can you stop the pattern of teaching on certain days and then stopping and preparing for the test on other days, but instead tie it all together?

Another reality is students entering high school with gaps in their knowledge. Even if kids are lacking in some skills they can still engage in rigorous mathematics. So how do we ensure that the task we put in front of them gives them the most opportunities, or coming into high school with interrupted schooling and/or limited English?

A lack of diversity in the teaching course, that's a goal, or a driver in some of the groups. And teachers entering classrooms from alternative certification programs—they don't all come in through schools of education. Some teachers come in through Teach for America and other alternative certification programs.

In Denver, we don't talk about strengths and challenges—we talk about glows and grows. A new phrase to add to your vocabulary – at least it's not another acronym. Three overall glows, from across the different RACs that I had the chance to sit in on. First, thinking about this connection of tasks, instructional strategies, expectations, beliefs, and mindsets as tightly connected. You can't separate them, so in all of the work that you do, whether it's on active learning and tasks and instruction or the modules that you're developing, all of these need to be wrapped together. That is what is going to help the teachers in the classroom. The second glow is the focus on equity. It was really inspiring to sit in for a short time yesterday afternoon on the Equity and Social Justice Working Group and listen to the work that they're doing. Maybe if you all work from the top down, and we work in K–12 from the bottom up, maybe we'll actually make it happen. Finally, I so appreciate your commitment to improving the mathematical experience of prospective mathematics teachers; it was heartening to sit in and listen to the passion that you all have in preparing teachers.

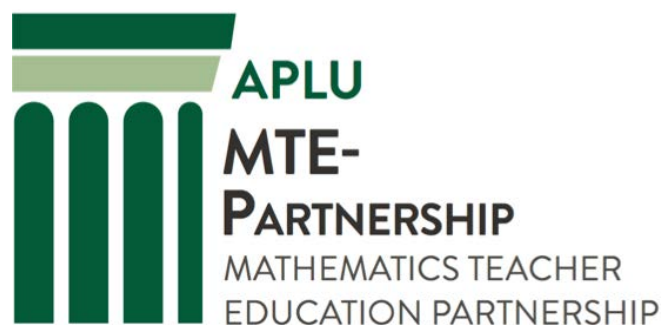
Now, three grows. I assume you all are, but if you're not already intimately familiar with three NCTM publications I highly recommend you get familiar with them. First, *Principles to Actions*, the eight effective mathematics teaching practices. Spend time in the book and go back and look at those productive and nonproductive beliefs. Look at the teacher and student actions, when a particular practice is applied in the classroom. A lot of you all talked about professional development for instruction in terms of the Active Learning in Mathematics, in terms of the MODULE(S²) group, and in terms of STRIDES. I heard it in all three so don't reinvent the wheel if you're talking about instruction in secondary mathematics; use what we're using in secondary mathematics. The second one, the new one, is *Catalyzing Change in High School Mathematics*. That's a must-read, also. There's a very interesting table inside that aligns the effective math teaching practices with equitable practices. The more that we can explicitly connect things for our students, whether they're your college students or our high school students, the more likely it is that they will stick. Finally, the *Impact of Identity in K-8 Mathematics*, which is where the five equitable math teaching practices come from. But, it really could be the impact of identity in K-12 mathematics, it's just that the vignettes are really more for elementary and middle school. I encourage you to go back to the taking action recommendations for principals, coaches, specialists and other school leaders in *Principles to Actions* and *Catalyzing Change in High School Mathematics*. I think that will give you all ideas that you can take forward.

A few things that I noticed while I was here was that I didn't hear you talk about academic language development. That was a missing aspect of how you think about the design of the modules or the design of the active learning lessons. I would encourage you to really give it some thought about supporting academic language development. Another thing, and I see it in the written materials that you have, is that you write about standards that you want to be aligned up with the Common Core, but I didn't hear anybody talk about the Common Core Standards or state standards while I was here. As a gentle reminder, you may want to pull that back up in your work with respect to the teachers because that's a really key part. It also struck me when I was in the Active Learning group, and I heard a couple people talking about how that while many of you have been able to get those first-year courses, the intro to calculus courses that kids take, down to 25 to 30 students, some of you haven't been able to do that and so you're really running the big lecture hall.

A resource that we're all about in K-12 right now is what we call SEAL—social, emotional, and academic learning. There are instructional routines that go along with it, which, in my mind, we could connect with the equitable teaching practices in thinking about engagement. We talk about three routines. The first is a welcoming ritual, such as the warm up in high school, but focusing on something social—how the kids can connect with someone else when they first come in the classroom, and have a conversation about, “so, as you thought about the homework, what questions did you have?” Anything just to connect with another person. The idea is that people, adults, come to these meetings or come to classes, and they just rush in but they need to ground themselves first before they can really engage in the learning. Another routine is engagement practices where throughout there is time to stop and engage in group discussion or talk with a partner. Maybe it's a turn and talk, or it could be some sort of brain break. At the end, there's this idea of an optimistic closure, where we try to close today in a way that we walk out optimistic about what's going to happen. So, “What did you learn, what questions do you still have?” Just any way to sort of reel kids in, ground them a little bit, engage them throughout, and then send them off in an optimistic way.

I'll close by saying thank you for all that you do to prepare teachers to come into our schools, and it's been great to have an opportunity to visit with you.

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