Proceedings of the Sixth Annual Mathematics Teacher Education Partnership Conference

The MTE-Partnership at Five Years: Growing Capacity for Continuous Networked Improvement

Wendy M. Smith
Brian R. Lawler
Janet Bowers
and
Lindsay Augustyn
(Editors)

APLU MTE-Partnership
Mathematics Teacher Education Partnership

June 25-27, 2017
New Orleans, LA
United States

Proceedings of the Sixth Annual Mathematics Teacher Education Partnership Conference

Edited by Wendy M. Smith, Brian R. Lawler, Janet Bowers, and Lindsay Augustyn

First published September, 2017

Published by the Association of Public and Land-grant Universities (APLU)

Proceedings available at www.aplu.org/MTE-P-2017-conference-proceedings

Articles published in the Proceedings are copyrighted by the author. Permission to reproduce an article or portions from an article must be obtained from the author.

ISBN: 978-1-5323-5553-0

Cite Proceedings Volume as:

Smith, W. M., Lawler, B. R., Bowers, J., & Augustyn, L. (Eds.). (2017). *Proceedings of the sixth annual Mathematics Teacher Education Partnership conference*. Washington, DC: Association of Public and Land-grant Universities.

Cite Proceedings Chapter as:

Author. (2017). Title of chapter. In W. M. Smith, B. R. Lawler, J. Bowers, & L. Augustyn (Eds.), *Proceedings of the sixth annual Mathematics Teacher Education Partnership conference* (pp. XX-XX). Washington, DC: Association of Public and Land-grant Universities.

Mathematics Teacher Education Partnership Co-Directors

Howard Gobstein, Association of Public and Land-grant Universities

W. Gary Martin, Auburn University

Mathematics Teacher Education Partnership 6 Planning Committee[1]

Howard Gobstein, Association of Public and Land-grant Universities, co-chair

W. Gary Martin, Auburn University, co-chair

Lisa Amick, University of Kentucky

Ed Dickey, University of South Carolina

Mark Ellis, California State University, Fullerton

Maria Fernandez, Florida International University

Dana Franz, Mississippi State University

Brian R. Lawler, Kennesaw State University

W. James Lewis, University of Nebraska- Lincoln

Alyson Lischka, Middle Tennessee State University

James Martinez, University of Tennessee, Knoxville

Julie McNamara, California State University, East Bay

Margaret J. Mohr-Schroeder, University of Kentucky

Jennifer Oloff-Lewis, California State University, Chico

Robert N. Ronau, University of Louisville

Wendy M. Smith, University of Nebraska-Lincoln

Marilyn Strutchens, Auburn University

Diana Suddreth, Utah State Department of Education

David Webb, University of Colorado at Boulder

Acknowledgements

Funding for the MTE-Partnership, including the 2017 Conference, was provided by the Leona M. and Harry B. Helmsley Charitable Trust.

Special thanks to Mary Leskosky of APLU for her assistance in planning and executing the logistics for the 2017 MTE-Partnership Conference.

Preface

These proceedings are a written record of the presentations and papers presented at the Sixth Annual Mathematics Teacher Education Partnership Conference held in New Orleans, June 25-27, 2017. The theme for the conference was "The MTE-Partnership at Five Years: Growing Capacity for Continuous Networked Improvement." We are pleased to present these Proceedings as a resource for the mathematics and mathematics education community.

www.mte-partnership.org

[1] W. James Lewis and Robert N. Ronau participated as members 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.

ISBN 978-1-5323-5553-0
90000>
9 781532 355530

CONTENTS

INTRODUCTION

OPENING ADDRESS

PANEL TALKS

RESEARCH ACTION CLUSTER REPORTS

Research Presentations

Presentation Abstracts

Closing Remarks

INTRODUCTION

The Mathematics Teacher Education Partnership: Six Annual Conferences and Counting

W. Gary Martin, Auburn University, martiwg@auburn.edu

Howard Gobstein, Association of Public and Land-grant Universities, hgobstein@aplu.org

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: an undersupply of new secondary mathematics teachers who are well prepared to help their students attain the goals of the Common Core State Standards for Mathematics (CCSS-M) (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) and other rigorous state mathematics standards. This consortium of over 90 universities and over 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, the role of the conferences in general, and the particular goals for the Sixth Conference held in June 2017.

An Overview of the MTE-Partnership

The initial concept for the Partnership was formed at the 2011 SMTI Annual Conference, which focused on how higher education might respond to the just-released CCSS-M, including necessary changes in teacher preparation. University programs participate in MTE-Partnership as a part of teams that include K-12 school districts and other partners involved in secondary mathematics teacher preparation, with a requirement that teams engage mathematics teacher educators, mathematicians, and K-12 personnel in their activities. The inclusion of multiple stakeholders in the efforts reflects the focus of the Partnership on "develop[ing] and promot[ing] a common vision and goals for how to best prepare teacher candidates who can promote student success in mathematics" within a program, as well as engaging in mutual learning and sharing responsibility across the Partnership (MTE-Partnership, 2014, p. 2). There are currently 39 partnership teams across 31 states in the 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 in response to several design challenges identified by the planning team, including (a) the need to maintain the engagement of the teams in the work of the Partnership and (b) the need to maintain a focus on disciplined inquiry consistent with the mission of universities (Martin & Gobstein, 2015). This design supports active collaboration by the Partnership teams to address significant issues in secondary mathematics teacher preparation using improvement science to ensure fidelity to academic standards of inquiry. NICs are distinguished by four essential characteristics (Bryk, Gomez, Brunow, & LeMahieu, 2015); each characteristic is described below, along with a discussion of how the Partnership addressed 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 MTE-Partnership programs by 40 percent by 2020. Note that the improvement target was set through a collaborative process of collecting data from the individual teams and programs. Further information on the measures used to assess candidate quality is given in a later section of this chapter.

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 MTE-Partnership, which is reflected in its Guiding Principles for Secondary Mathematics Teacher Preparation (MTE-Partnership, 2014). This document then formed the based for identifying challenges in secondary mathematics teacher preparation. A multi-step process described by Martin and Strutchens (2014) led to the identification of four significant problem areas of primary importance to the Partnership. In the second column of Figure 2, these problems are restated in the positive as primary drivers, the Partnership's main areas of influence necessary to promote movement towards achieving the aim (Bryk et al., 2015), which is given in the left-most column. Note that these primary drivers are well-aligned with the Standards for Program Characteristics and Qualities in the Standards for the Preparation of Teachers of Mathematics released by the Association of Mathematics Teacher Educators (AMTE) (2017).

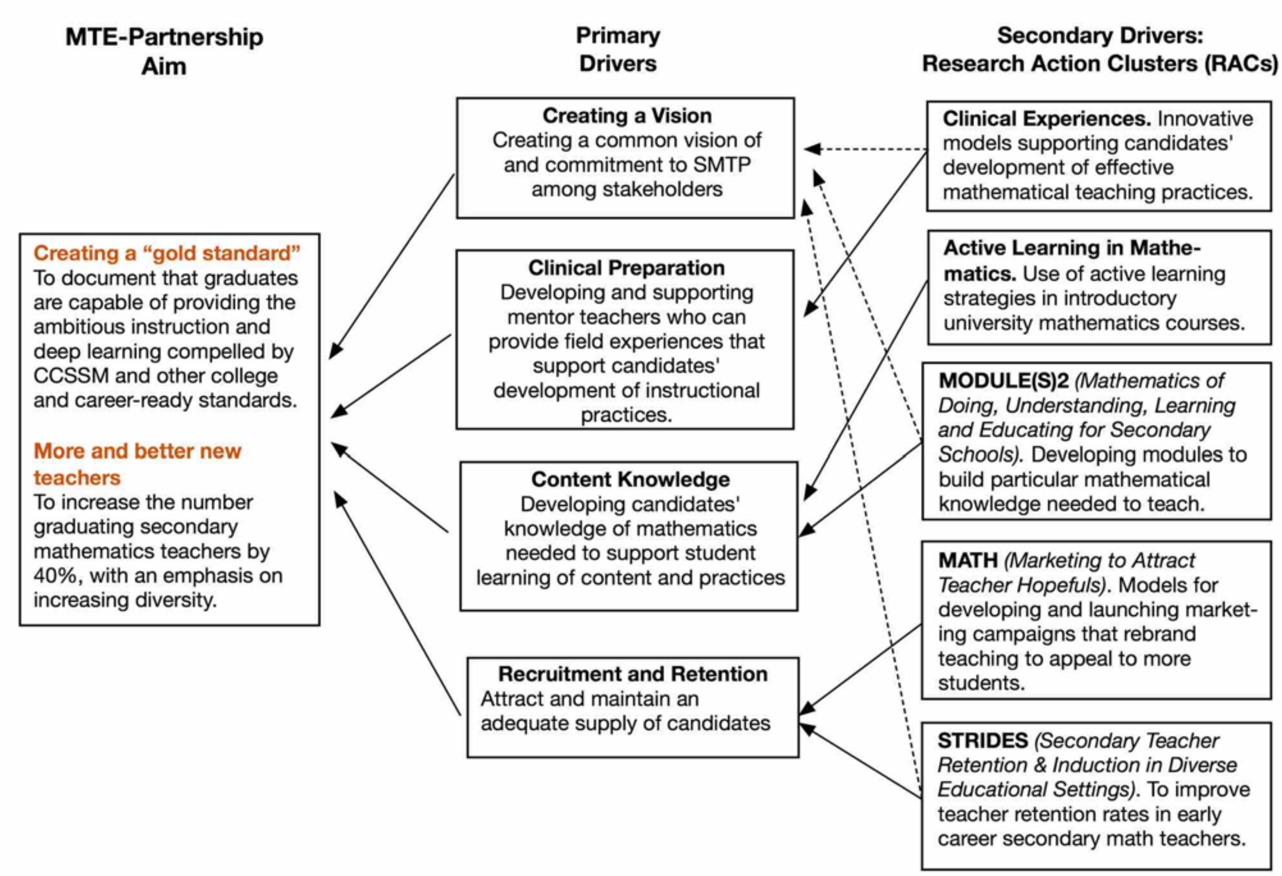


Figure 2. The MTE-Partnership driver diagram (Martin & Gobstein, 2016).

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. Note that each RAC has developed its own aim statement and driver diagram, and undertakes PDSA cycles in alignment with its driver diagram. In some sense, the RACs may be considered "sub-NICs."

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 a small number of settings. As its efficacy is demonstrated, it is tested in an increasing number of settings, noting adaptations that are needed due to differences in the context. Eventually, the interventions designed should be useful by teams across the Partnership. Further note that the structure of the network allows a "divide and conquer" approach in which subsets of teams can address different problem areas, providing teams access to a wider range of interventions as the work of the RACs progresses.

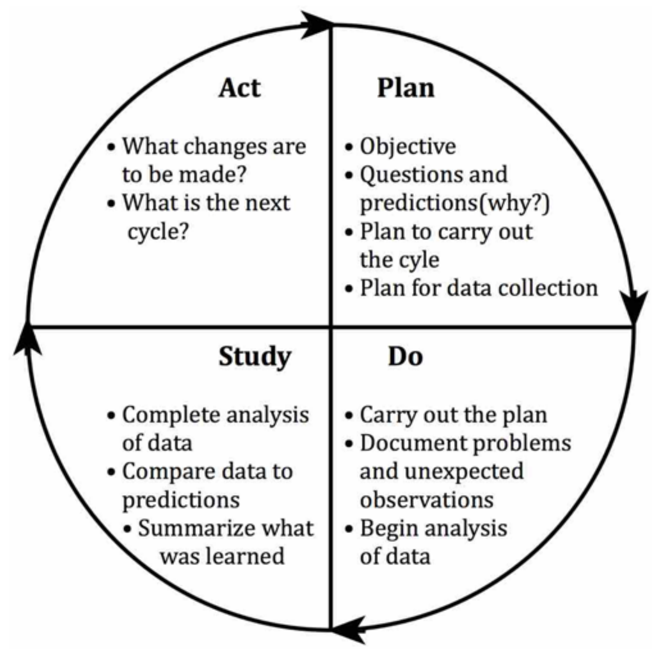


Figure 3. The Plan-Do-Study-Act (PDSA) Cycle. (Adapted from Langley, 2009)

The Role of the Annual Conferences

While the work of the MTE-Partnership carries on throughout the year, 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 and set forth plans for the coming year. A brief outline of the previous six conferences follows, following the developmental trajectory of MTE-Partnership; a more detailed account can be found in the introduction to the Proceedings of the 5th 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 MTE-Partnership, which led to the Guiding Principles for Secondary Mathematics Teacher Preparation (MTE-Partnership, 2012), since updated in 2014, the central organizing document for the Partnership described above. A first attempt was also made at identifying central challenges in meeting the guiding principles; follow-up work led to the development of the four primary drivers discussed above.

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" was used to initiate their work.

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. 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 which was sunsetted. 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. Perhaps unsurprisingly, 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.

Goals of the 2017 Conference

The sixth 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 keynote by Jennifer Russell highlighted the importance of the NIC design and its role in supporting program change. Teams were consequently challenged to consider their progress toward program transformation during a working dinner. A working session on transformation was also held at the end of the second day.

Research Action Clusters (RACs) will continue their work and consider how to share it to contribute to additional teams' transformational efforts. This goal is central to the work of MTE-Partnership, given that the major work of improvement happens within the RACs. The RACs spent more than seven hours of working over the conference, central to their work in progressing toward their respective aims. The RACs were particularly asked to consider how they might contribute to the broader focus on program transformation. Updates on their progress can be found in the Research Action Cluster Reports section of the 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 to 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 overall aim and purpose of the Partnership, as well as its accomplishments, in their opening and closing remarks, and breakout sessions were devised to allow cross-RAC sharing (as well as to also orient participants new to the Partnership to the RAC in which they were participating). Brief research reports were again included to build understanding of the work going on across the Partnership. Finally, the conference reactants provided a broader cross-RAC lens in their final remarks.

Specific focus on equity and social justice will be included throughout the proceedings. To continue the emphasis on equity and social justice, a panel discussion was held in which representatives of the RACs discussed ways in which issues related to equity and social justice occurred in their work. Nicole Joseph provided a reaction to the panel, providing further insights into how these issues might be better addressed. She subsequently visited the RACs throughout the conference and served as a conference reactant, providing further insights on equity and social justice. Each of the RACs was encouraged to further discuss ways in which equity and social justice might be included. Finally, an Equity Working Group was launched prior to the conference and organized a discussion group at the end of the first day. This group continued its work in a post-conference meeting in which it undertook the initial development of an aim and driver diagram.

Final Reflection

While much of the activity of the MTE-Partnership now occurs within the RACs, over the years the conferences have served an important role in establishing and catalyzing the Partnership's vision and direction. Moreover, they have continued to serve an important role beyond supporting the work conducted in RACs, as they have brought together participants across the RACs to share their ongoing work. This has both provided opportunities to cross-pollinate efforts across the RACs but also to develop a sense of shared identity and commitment to the broader MTE-Partnership effort, beyond participation in one aspect of its work. In addition, they have served to highlight new areas of concern for the Partnership, such as program transformation and equity and social justice.

The effectiveness of the conferences 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 six annual conferences*:

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

While the planning team members were extremely heartened by these results, planning is already underway for how the 2018 conference might be made even more effective in continuing to push forward the work of the Partnership in transforming secondary mathematics teacher preparation.

References

Association of Mathematics Teacher Education. (2017). *Standards for preparing teachers of mathematics*. Raleigh, NC: Author.

Bryk, A., Gomez, L. M., Grunow, A., & LeMahieu, P. (2015). *Learning to improve: How America's schools can get better at getting better*. Cambridge, MA: Harvard Education Press.

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.

Langley G. L., Moen, R., Nolan, K. M., Nolan, T. W., Norman, C. L., & Provost L. P. (2009). *The Improvement guide: A practical approach to enhancing organizational performance* (2nd ed.). San Francisco, CA: Jossey-Bass Publishers.

Martin, W. G. & Gobstein, H. (2016). The MTE-Partnership story as revealed through its conferences: An overview of the Partnership and the 2016 conference. In B. Lawler, B. Ronau, & M. Mohr-Schroeder (Eds.), *Proceedings of the Fifth MTE-Partnership conference*. Washington, DC: Association of Public and Land-grant Universities.

Martin, W. G., & Gobstein, H. (2015). Generating a networked improvement community to improve secondary mathematics teacher preparation: Network leadership, organization, and operation*. Journal of Teacher Education*, *66*(5), 482-493.

Martin, W. G. & Strutchens, M. E. (2014). *Priorities for the improvement of secondary mathematics teacher preparation for the Common Core era*. Paper presented at the AERA Annual Meeting. Retrieved from http://www.aera.net/Publications/OnlinePaperRepository/AERAOnlinePaperRepository/tabid/12720/Owner/314509/

Mathematics Teacher Education Partnership. (2012). *Guiding principles for secondary mathematics teacher preparation.* Washington, DC: Association of Public Land Grant Universities. Retrieved from http://www.aplu.org/projects-and-initiatives/stem-education/SMTI_Library/mte-partnership-guiding-principles-for-secondary-mathematics-teacher-preparation-programs/File

Wilson, S., & Martin, W. G. (2011). *The Common Core State Standards and teacher preparation: The role of higher education*. Washington, DC: Association of Public and Land-grant Universities.

Overview of the Conference

Wendy M. Smith, University of Nebraska-Lincoln, wsmith5@unl.edu

The sixth annual Mathematics Teacher Education Partnership (MTE-Partnership) conference was held at Hotel Monteleone in New Orleans, LA, from June 25-27, 2017. With 99 registrants from 32 of the 39 MTE-Partnership teams, the theme for this year's conference was "The MTE-Partnership at Five Years: Growing Capacity for Continuous Networked Improvement."

In support of the partnership aim, the goals for the 2017 annual conference were:

- 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 25, with a joint plenary presentation shared by the Science and Math Teacher Imperative (SMTI) conference; Jennifer Lin Russell from the University of Pittsburgh presented what the field knows about networked improvement communities in her talk, "Organizing for Improvement." Russell has been involved with Networked Improvement Community (NIC) work for over a decade; as more research emerges, NICs appear to be one of the most promising approaches to solving complex problems of practice in education. NICs provide both a technical and social structure for professional learning communities, and go beyond a series of Plan-Do-Study-Act (PDSA) cycles to nurture community norms, connections and identities. The Opening Address section of these proceedings gives the full text of this plenary talk.

During the Sunday dinner hour, MTE-Partnership teams were seated together; Gary Martin of Auburn University shared a brief overview of the new (2017) Association of Mathematics Teacher Education (AMTE) *Standards for the Preparation of Teachers of Mathematics.* Teams were asked to reflect on how close their local teacher preparation programs are to achieving the AMTE standards, and where their teams are in the transformation process. Each team was asked to articulate goals for their attendance at the conference: What information or connections align with desired outcomes?

After the Sunday dinner, Research Action Clusters (RACs) met up informally to share progress with one another and discuss plans for efficiently utilizing RAC work time over the next two days. The Research Action Cluster Reports section of these proceedings provides the history and current work of each RAC.

On Monday, June 26, the MTE-Partnership conference began with a plenary session that first featured Martin sharing more information about the new AMTE standards. Released in February of this year and available at http://www.amte.net/standards/, the *Standards for Preparing Teachers of Mathematics* (SPTM) align quite will with the MTE-Partnership Guiding Principles. AMTE decided to write standards after determining that, despite many recent efforts to provide insights into what beginning teachers should know and be able to do (e.g., The *Mathematical Education of Teachers II* [CBMS, 2012], *NCTM/CAEP Standards for Mathematics Teacher Preparation* [secondary, 2012], *Principles to Actions* [NCTM, 2014], and *Common Core State Standards* (2010]), what is missing is a comprehensive description of the preparation of teachers of mathematics. The standards describe a national vision for the initial preparation of all teachers (Pre-K–12) who teach mathematics, including those not necessarily certified to teach mathematics. The standards are aspirational, rather than describing minimum levels of competency needed by beginning teachers. The standards are grounded in five main assumptions about the goals of teacher preparation: programs have a deep, integrated focus on equity; teachers develop a stance of career-long learning; programs have a central focus on mathematics; teacher preparation is the responsibility of multiple stakeholders; and programs should commit to improving effectiveness. The last chapter of the standards discuss program transformation; the Transformations Working Group (report in the Equity Panel and Working Groups section of these proceedings) is closely aligned with the AMTE vision for program transformation.

Also on Monday morning was an update from Ed Dickey (retired) and Yvonne Lai (University of Nebraska-Lincoln) regarding the National Council of Teachers of Mathematics (NCTM) *Pathways Through High School Mathematics* committee and ongoing work. Both Dickey and Lai are members of the NCTM High School Mathematics Task Force, chaired by Karen Graham (University of New Hampshire), which is charged with the following:

- Identify, describe, and document the range of problems and challenges that are faced in ensuring that grades 9-12 mathematics works effectively for each and every student;
- Develop a set of overarching, specific, and implementable recommendations for addressing these problems and challenges;
- Provide specific options for implementing the recommendations that serve as a framework for discussion by teachers, curriculum and professional developers, and administrators; and
- Build on the following foundational documents such as the Common Core State Standards (CCSS-M, 2010), Principles to Actions (NCTM, 2014), Focus on High Mathematics with reference to Common Vision (Transforming Post-Secondary Education in Mathematics [TPSE Math]), Dana Center Mathways, Guidelines for Assessment and Instruction in Statistics Education (GAISE), and Guidelines for Assessment and Instruction in Mathematical Modeling Education (GAIMME).

To achieve these charges, the task force's goals include: (1) produce a document comparable to *Principles to Actions* addressing the charge; (2) plan for follow-up publications and resources; (3) provide support and guidance for professional development based on recommendations; and (4) provide support and guidance for NCTM Summer Institutes. The task force convened in December 2016, and has had a number of ongoing subcommittee and working group meetings. The goal is to have documents ready for public review and comment in Fall 2017, with final drafts ready for release at the April 2018 annual NCTM meeting in Washington, DC. MTE-Partnership members are encouraged to watch for the release of drafts in Fall 2017 and to provide feedback to the task force. Additionally, MTE-Partnership members can be thinking about how essential standards and various pathways might be implemented.

NCTM has reframed Access and Equity to include Empowerment, to capture the critical constructs of identity, agency, and social justice. NCTM is working collaboratively with many organizations to issue a call for collective action for equity and social justice in mathematics education with the National Council of Supervisors of Mathematics (NCSM), AMTE, TODOS: Mathematics for All, North American Study Group on Ethnomathematics (NASGEm), Journal of Urban Mathematics Education (JUME), and others.

Following the NCTM Task Force presentation was an Equity Panel discussion, in which panelists representing several of the RACs reported their research activity related to equity issues. Each panelist's talk is summarized in these proceedings: Mark Ellis (California State University, Fullerton), Matthew Voigt (San Diego State University), Maria Fernandez (Florida International University), Joleigh Honey (Salt Lake City School District) and Fred Uy (California State University, Los Angeles), with Nicole Joseph (Vanderbilt University) serving as panel discussant.

The remainder of Monday morning was spent with the RACs giving short presentations so that MTE-Partnership conference attendees could learn more about the scope and ongoing work of two different RACs. RAC reports are included in these proceedings. After lunch on Monday and all of Tuesday morning were times for RACs to work on their specific agendas.

Monday afternoon featured three sets of concurrent presentations by MTE-Partnership members, in 15 different presentations. Each of these presentations (abstract and/or full article) are included in these proceedings.

Finally, Tuesday's closing session featured reactions by Dickey, Josh Males (Lincoln Public Schools), and Joseph. These reflections are in the closing section of these proceedings.

Of note, the Equity and Social Justice Working Group stayed one day after the conference to begin to identify the "equity problem" in the preparation of secondary mathematics teacher, and develop a driver diagram to lead a future research agenda. A summary of the Equity and Social Justice Working Group's current work is in the Panel Talks and Research Action Cluster Reports sections of these proceedings.

Overall, evaluations of the 2017 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 2017 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.

References

Association of Mathematics Teacher Educators. (2017). *Standards for preparing teachers of mathematics.* Available online at http://amte.net/standards

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.

Conference Board of the Mathematical Sciences. (2012). *The mathematical education of teachers II*. Providence, RI and Washington, DC: American Mathematical Society and Mathematical Association of America.

National Council of Teachers of Mathematics (NCTM). (2014). *Principles to actions*. Reston, VA: Author.

Opening Address

Organizing for Improvement: Reflections on the Power of Networks

Jennifer Russell, University of Pittsburgh, jrussel@pitt.edu

I'm so honored to be here and to have this opportunity to talk with you about some of my reflections about the power of improvement networks for driving change in education. I've been a long-time observer and admirer of the work of the MTE-Partnership, and so it's particularly meaningful for me today to be speaking with this group. And I'm now very intrigued to learn even more about the ASCN group, so thank you to both. I also want to thank Gary and Howard for this invitation.

I've organized my talk around four reflections on Networked Improvement Communities (NIC). NICs are a structured form of network that are organized to address a very specific problem of practice. The original concept was introduced by Tony Bryk, Lewis Gomez, and Alicia Grunou from the Carnegie Foundation for the Advancement of Teaching, and there's been incredible interest in this NIC concept in the field of education. Over a thousand people recently came together at Carnegie's national summit on improvement, and this community interest is growing rapidly. I've had the great fortune to be in the work from the beginning, and the opportunity to observe and study a number of these emerging improvement networks. Reflecting on this work, I'm going to argue today that first, NICs are a highly promising approach for solving complex problems of practice in education. Next, I'll argue that NICs provide a technical and a social structure for fostering the development of what we're increasingly calling a "scientific and professional learning community." Then I'll argue that the technical work of NICs is more than a series of individual Plan-Do-Study-Act inquiry cycles, kind of correcting what I think is a bit of a misconception about the work that's out in the field. And finally, I'm going to argue that networks need to nurture social connections, norms, and identities, when growing scientific and professional learning communities.

Before I dive into that main argument, I'll tell you a bit about my work with networks that motivated these reflections. First, I come to these reflections from the perspective of a developmental evaluator. For the past seven years, I've been engaging in the developmental evaluation of NICs, so I've been tracking their development, studying their health, and engaging in rapid analytic and feedback cycles to network leaders to help them shape their ongoing networks. I started to do that work with Carnegie's first NIC, the Carnegie Math Pathways Project, and then continued with their second network, the Building of Teaching Effectiveness Network. Currently, I'm leading a developmental evaluation team for two of what I call "second-generation" NICs, and these are networks that are started by organizations other than the Carnegie Foundation. The first is the Tennessee Early Literacy Network (TELN) and the second is the Better Math Teaching Network. I'm going to refer to these, what I'm learning in these developmental evaluations about these two networks in my talk today, so just a little bit of background about both. TELN was launched by the Tennessee Department of Education, who was looking for a way to reshape the relationship that the state department had with school districts, thinking about new ways that states could support school districts to support statewide instructional improvement. Tennessee Department of Ed and its regional offices are working with district and school teams to improve the proportion of students who are proficient in literacy by Grade 3. The second network, the Better Math Teaching Network, was launched by Kirk Walters and Toni Smith at the American Institutes of Research, with support from the Nellie May Education Foundation, and it seeks to improve student engagement in Algebra 1 in New England through student-centered math teaching and learning strategies. It is a network of high school mathematics teachers and then in parallel there's a network of leaders who will work with those teachers to scale up the innovations that they develop.

I also come to this work as a scholar of educational organizations. I started my interests, as Howard mentioned, in networks by studying math teachers' professional networks. Who do they go to for advice about their mathematics teaching, and how do they gain access to resources for improvement through those networks? I'm still doing that work, but now I've added this strand of research on improvement networks that are interorganizational networks, networks that bring organizations together. And I'm trying to develop theory about how these networks--these improvement communities develop and how their structure shapes their capacity to achieve their aims. Through this line of research, I've worked with Tony Bryk and colleagues at Carnegie to posit a theory about the key components of a NIC as an organization.

Finally, I've come to these reflections from the perspective of a network leader. I'm currently a principal investigator for an IES-funded project called the Tennessee Math Coaching Project. My co-investigators are Mary Kay Stein and Rip Correnti from the LRDC; Victoria Bill from the Institute for Learning, which is a professional development organization also in our center at LRDC; and then Nate Schwartz and Vicki Kirk from the Tennessee Department of Ed. For the last two years, we've been testing and refining a model for mathematics instructional coaching that can be a resource for districts throughout the state. This work is a deep collaboration. All three organizations are prime investigators in the project. And we've iteratively refined our coaching model in collaboration with a network of coaches that are stretched throughout the state of Tennessee. And so I'll also use this work in examples in my talk.

On to my argument. My first reflection is that NICs are, in fact, a highly promising approach for solving complex problems of practice in education. I don't want to dwell here too long, because I think the MTE-Partnership group, in particular, has kind of bought into this way of organizing, but I do want to say that I've been examining various research practice partnership models and networks in education and it's made me increasingly confident over time that this is a really productive strategy to address complex problems. This is an insight that Howard and Gary and colleagues had when they heard about the NIC concept and thought it provided a strong model for the MTE-Partnership work. And in a recent article that we wrote for Phi Delta Kappan and that I wrote with Louis Gomez, Tony Bryk, Paul LeMahieu and others from Carnegie, we argue that NICs are the right type of network to form if you want to address complex systems problems and you need to organize for collective action. You need to get multiple organizations of different types together that have different types of expertise, but also different working traditions, all moving in the same direction, working together to solve a problem. We argue that NICs are the right type of networks for certain types of problems. In this paper, we distinguish tame problems versus wicked problems. Tame problems can be clearly stated and exhaustively formulated before the start. But wicked problems have multiple causes and the path to solving them can't be stated from the beginning. A tame problem can be solved by picking the right solution and then working on implementation, but wicked problems don't have known solutions. Progress is made through disciplined inquiry rather than applying straightforward and known applications. And the MTE-Partnership is really trying to address a wicked problem: improving math teaching and learning at scale. And starting at higher education and moving all the way into K-12 education, is a very complex problem. In this article, we spotlight the work of MTE-Partnership as an example of the right network for this type of problem, because we believe that MTE-Partnership is an important model for the field of how to use this NIC concept.

For my second argument, and this is a reflection, my second reflection is that NICs provide both a social and a technical structure for fostering the development of a scientific and professional learning community. Catalyzing and operating a NIC is ultimately in the service of creating a learning organization, or a learning community, which accelerates the capacity to improve practice and address these complex problems. So, let's unpack that. Here's a simplified version of the NIC model (see Figure 1).

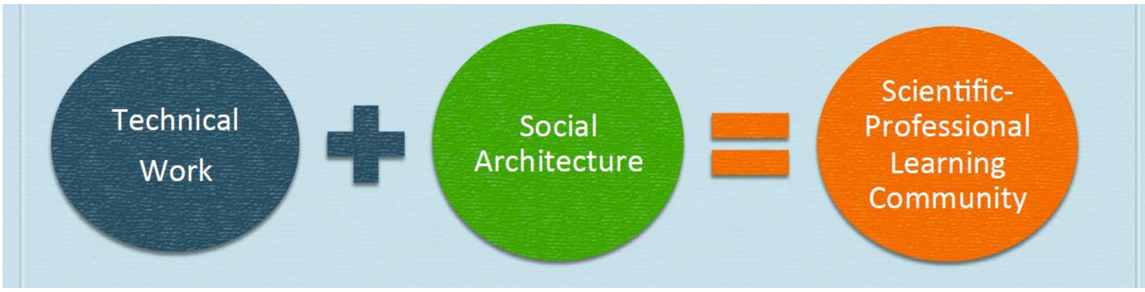


Figure 1. The NIC equation.

Very simplified. If only it was this easy, right? At the far left, you've got the technical work we talk a lot about. That's the improvement work, specifying driver diagrams, engaging in inquiry cycles, all of that. Very important. But NICs also have a social side. The model has something to say about how we organize people and organizations to accomplish the technical work. And we've started recently talking about the outcome of all this effort of putting that technical work and social structure in place as a scientific and professional learning community. This type of community draws on the concepts of professional learning community and communities of practice, something we're pretty familiar with in the education field. But to that concept, we add the characteristics of a scientific community, like the communities many of us are a part of as we conduct our research.

So, what does it mean to be a professional learning community? We think about these as communities with a commitment to a common problem of practice that have open and productive information and communication exchanges that engage in social learning. And members align their professional practices over time as their shared practical knowledge grows. Scientific communities are consistent with those dimensions of professional learning community, but they're also distinctive in some critical ways. Work is guided by a common theory. The work leverages what is known from prior research. There's this accumulation and building of knowledge. The learning happens as members of the community engage in disciplined inquiry using the scientific methods. And the community has mechanisms to ensure that accumulating knowledge is shared broadly in the field. If you pause for a minute to reflect on that, think about: In what ways does the work in your network or your research action cluster, or even the MTE-Partnership more broadly, embody this notion of scientific and professional learning community?

I think this concept of scientific professional learning community helps us to ground the NIC work in theory and research that resonates with the education practice and research communities, and may be a productive way to reflect on what we're trying to do. I'll be curious to see if you agree with that, and maybe it's something we can pick up in discussion at the end. Now, I'm going to return to the NIC equation and share some reflections I've had on the technical improvement work of these NICs.

There are lots of different organizations that are trying to launch or run NICs and get very focused on PDSA cycles, which are short-cycle improvement cycles where individuals or small groups come up with an idea, test it out, collect some data, and learn from it. But I want to argue that systematic and intentional improvement work is much more than a series of PDSA cycles. Here's that visual that I flashed earlier.

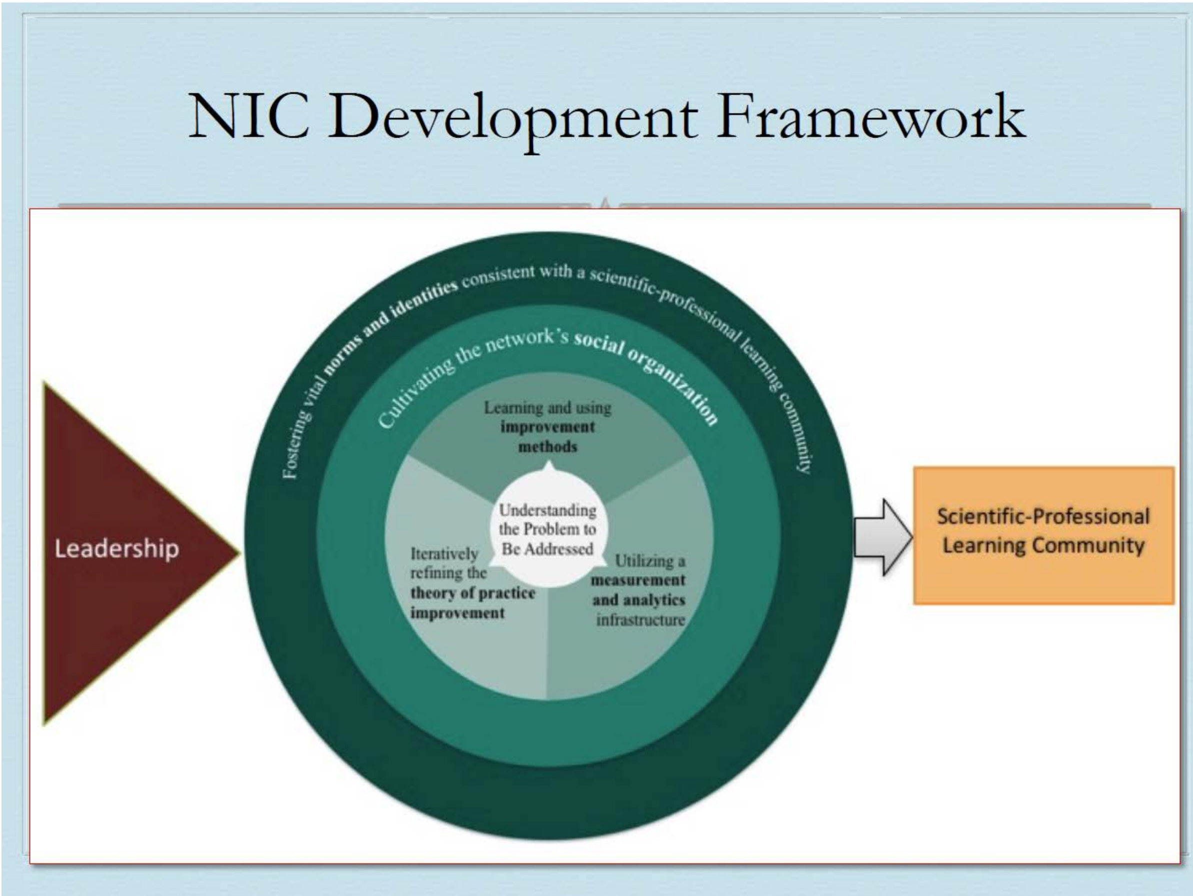


Figure 2. NIC development framework.

It's the visual of our NIC development framework (see Figure 2). And it aims to identify the key organizational dimensions of an NIC. Briefly, on the left you see the red wedge is leadership. It's driving the social and technical work that's described in the bulls-eye, and it's all in service of developing a scientific and professional learning community. I'm going to zero in on the center of the bulls-eye, that part of the framework. It's the inner circle and those three surrounding triangles. We call this the NIC technical core, the technical work of the NIC. The key components of that are: understanding the problem to be addressed, specifying and iteratively refining a working theory of improvement, learning and using improvement research methods, and utilizing a measurement and analytics infrastructure. I emphasize that the technical work, the improvement work of a NIC, is more than just a series of PDSA cycles. It includes ongoing reflection on the problem of practice and reflection with data and what we're learning through our improvement work. It's guided by a working theory of improvement. Process mapping is a key part of this technical work; it illuminates the key system elements that we might target for improvement. And then this notion of Plan-Do-Study-Act cycles or inquiry cycles are also important in testing changes and for adaptive integration.

My colleagues at Carnegie and I are increasingly convinced that improvement work really must begin with a deep understanding of the problem that you're trying to solve. But this should extend beyond the initial development of a network. You might have engaged in an activity like this where you were brainstorming the causes of a problem, putting them on post-it notes. This is from the Tennessee Early Literacy Network, where district teams were, you know, coming up with ideas about what's the root of the early literacy problem in our schools? And then network leaders engage in a process where they organize those root causes into a fishbone diagram where the different spines are different causes, broader categories of the types of the problem. And this often happens at the beginning of these improvement networks, but sometimes gets forgotten. It's sometimes an early step that we kind of leave behind as we get into trying to solve the problem. But there are other systematic ways to develop a deeper understanding of the problem. In the Tennessee Early Literacy Network, that included deep examination of data on literacy achievement trends. And even though this is a relatively new network that started in November and was then officially launched with the school and district teams, we're still investigating the problem itself, trying to understand what the data says about what's going well in what parts of the system, where are the real problems, how can we understand the variation and performance in a system?

Another key component of this idea of understanding the problem is getting the user perspective. And in TELN, we've used an interesting technique called the journey maps to understand how students and teachers are experiencing their systems. In particular, I'll talk about the student journey maps. The district leads in this network identified individual students who had gotten to third grade and were not proficient readers. And they picked a third-grader. They reviewed student records, the support services they had received, their attendance patterns, anything about their families. They talked to the student's teachers, both current and prior. They interviewed the student themselves, and tried to understand experiences with literacy instruction and with school more broadly. And then they wrote up what they learned. Then district leads posted these in a blog space, which enabled social learning where people learned from the different cases of students.

This is a nice complement to the kind of macro-level data that we often have in systems. We can see this school has higher literacy rates than this one. This is about getting at it from the ground, from the user perspective. You might think about how you might get the user perspective in your work. What does it feel like to be a mentor teacher or a student teacher? What is the first year of a beginning math teacher's life feel like? Or what's it like to be a veteran teacher who's had a career of traditional math teaching approaches and now is being asked to teach rich, open-ended practices? There's a lot to learn about the problem by getting to that, toggling between the macro trends and the individual user. And this is something that we think should be revisited at different time points in the life cycle of an improvement community. It's critical to build routines to continue to learn about the problem. Some of this comes naturally as you start to intervene in your systems and test promising solutions. You naturally learn through the way that systems respond. And then that learning feeds back into continuing to update things like your fishbone diagrams or those public representations of the problem that help bind your community together and build a shared understanding of what you're doing.

A second critical component of the NIC technical work is the work related to a working theory of improvement. I think most of you are familiar with the driver diagram concept. And we think of driver diagrams as a specification of the working theory of improvement. And what's critical is making sure that these are living theories that guide improvement work and networks. Again, I'll illustrate this using the working theory of improvement from the Tennessee Early Literacy Network. Here's the aim of that network (see Figure 3).

They are trying, by 2022, to have 80 percent of students in the participating districts proficient in third-grade literacy. And through that specification of the problem, they identified four drivers. They specified primary drivers, and the theory is if we improve those primary drivers, we're likely to achieve our aims. It's a theory that we're testing as the work unfolds, but it provides a way to coordinate the work. Now, the TELN network leaders targeted one of the drivers to get started with the improvement work of the network. They identified support for struggling students as a great place to start. As we're launching these improvement networks, we can't really do it all at once. It's a tricky thing to tackle the whole of a problem all at once, and TELN zeroed in on support for struggling students very strategically. It was likely a place where we could get a quick win, which helps to build the motivation and engagement of the people working on the problem. And, you were probably going to get traction

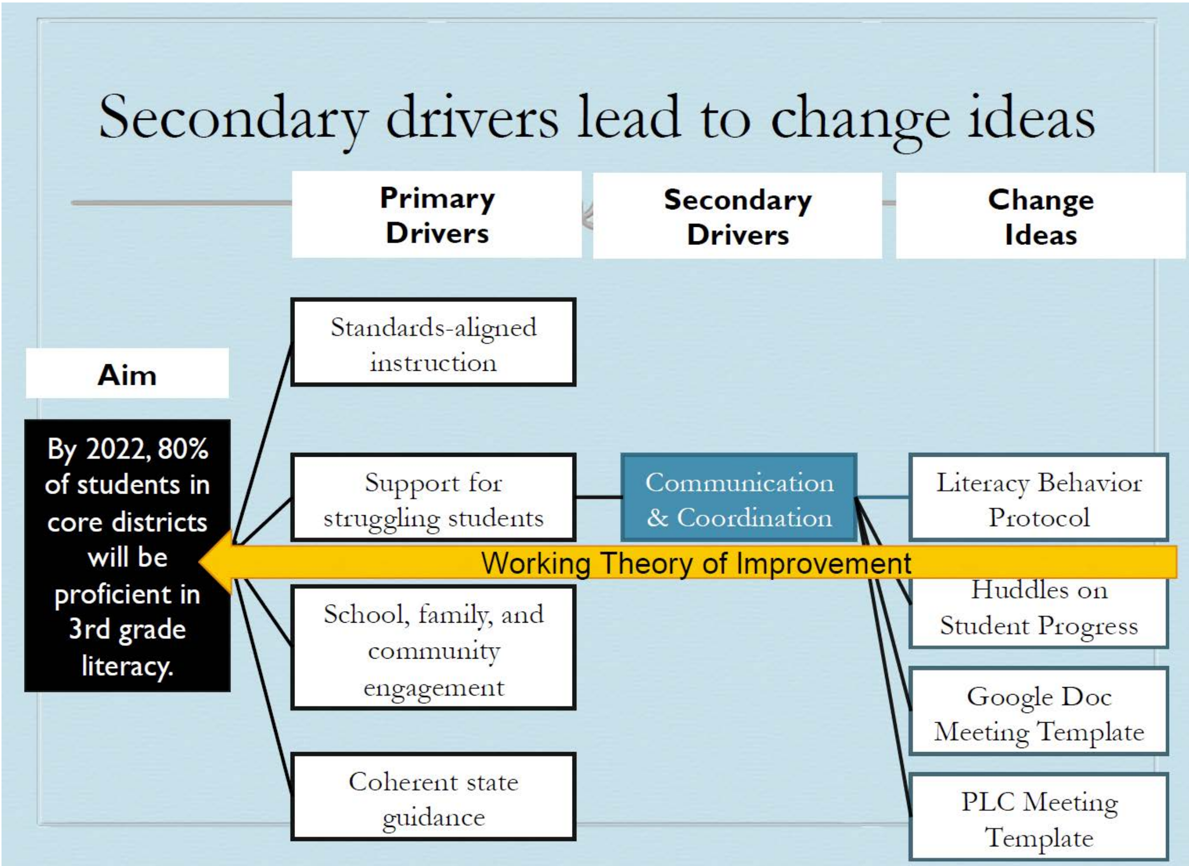


Figure 3. Driver diagram.

on those supports for struggling students. Think about the RTI systems in schools, that's the kind of supports for struggling students. We're probably going to get quicker wins there than standards-aligned instruction; getting teachers all using strong teaching practices is probably a longer-term driver to address.

They started with supports for struggling students and focused on a secondary driver, communication and coordination, because this is where lots of inefficiency, confusion, frustration, kind of falling through the cracks issues, arise, when providing extra supports for students. And then the network hub identified three potential change ideas that school teams could test in order to improve communication and coordination. These came from research, from peoples' practical knowledge. If you follow a line all the way through, you see a working theory of improvement that these system changes are expected to improve communication and coordination, which we theorize will improve supports for struggling students, which in turn will contribute toward the aim.

The driver diagram then should serve a kind of disciplining function for the network's work. It should be a way to generate these change ideas. It should be a way to provide coherence for the diverse work teams that are working on different components of the problem. And it's a working theory of improvement because it should be revisited and updated as you learn about the systems that produce the problem and the change ideas that are proving to be most visible. This idea of a working theory of improvement is critical to fostering these scientific and professional learning communities.

In the network that I helped to catalyze through the Tennessee Math Coaching Project, we utilized a different representation. We did not use a driver diagram. This math coaching model (see Figure 4) is our theory.

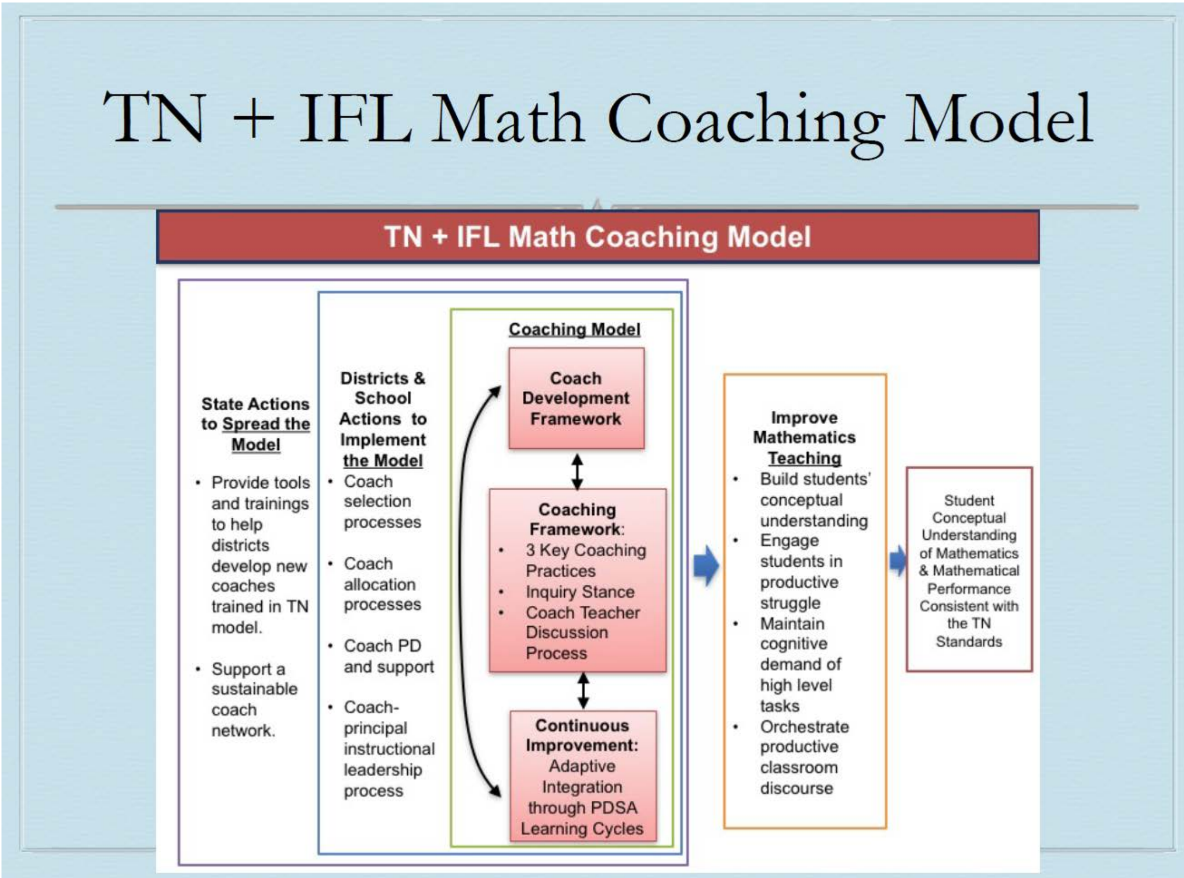


Figure 4. Math coaching model.

We specify on the right our goals, our student conceptual understanding and math performance consistent with the Tennessee standards, which are similar to the Common Core standards. We take a stance on the type of mathematical teaching that we think will contribute to our aim, building student conceptual understanding, engaging students in productive struggle, maintaining the cognitive demand of high-level tasks, and so on. In the center, we specify our mathematics coaching model in the green box, and that specifies a way of training coaches. We have key coaching activities that we've identified through continuous improvement research, and we have a stance toward the adaptive integration of the model into diverse local contexts. And then the outer boxes, we specified the elements of school, district, and state contexts that support this type of coaching. So regardless of the representation, it's important to have a public visualization that represents your working theory of improvement, so it coordinates the work that you're doing in your network.

Another key component of improvement work that I think is underutilized as we talk about NICs is the process map. The improvement science approach, the kind of method that NICs leverage, is really good for identifying and improving high-leverage processes and routines. But we don't often think about processes or routines in education. Teaching is often viewed as a dynamic art, not a set of routine processes. However, if we analyze practice, we see repetitive routines that can be targeted for improvement work. One I like to think of is Peg Smith's work on the structures and routines of a lesson, of how teachers can engage students in high-level tasks where students have some individual time, work in groups, then there's public representations of solution strategies. That has an embedded routine. In our coaching work, a key routine is the coaching cycle. And this is a common way of thinking about a coaching cycle. There's a pre-observation planning conference, then the coach observes the teacher teaching a lesson. And then they have a feedback conference. And then that all repeats in the next cycle. As we got into Tennessee and started working with coaches, we saw that many of them were not doing that first step. They were doing an observation and then providing some feedback in a follow-up conference.

We also found that these cycles didn't really build on each other. They didn't connect to another cycle. They weren't specifying a goal for the next cycle of coaching work. It looked more like observation, conference, and then maybe again another observation, conference. For two years we engaged in iterative improvement cycles, elaborating components of this coaching cycle to provide guidance for coaches. We identify key coaching practices inside the phases of the process. For example, during the pre-lesson planning conference, coaches engage in what we call "deep and specific discussion of the instructional triangle: mathematics goals and pedagogy and student learning." And we refined this even further, identifying key aspects of high-depth discussions, which we call "rigor factors," like thinking ahead of time about likely student solution paths for a task. These rigor factors in our analytic work predicted teaching improvement. When coaches and teachers were having these deep discussions and really doing these things well, they were more likely to see teaching gains. Additionally, we've explored other aspects of the process, such as getting specific about the amount of time coaches should expect to carve out for each phase of the process and what it takes to be done with quality. We didn't use individual PDSA cycles to refine the model. Rather, it was a more centralized endeavor where the network hub reviewed video tapes and other artifacts of coaching practice, started to generate some learnings, shared it with coaches. They tried out some of the practices more broadly that we identified, and it went in that way, data-based improvement cycles using many traditional research methods such as content analysis and relational statistical analyses. And that helped us iteratively refine this process.

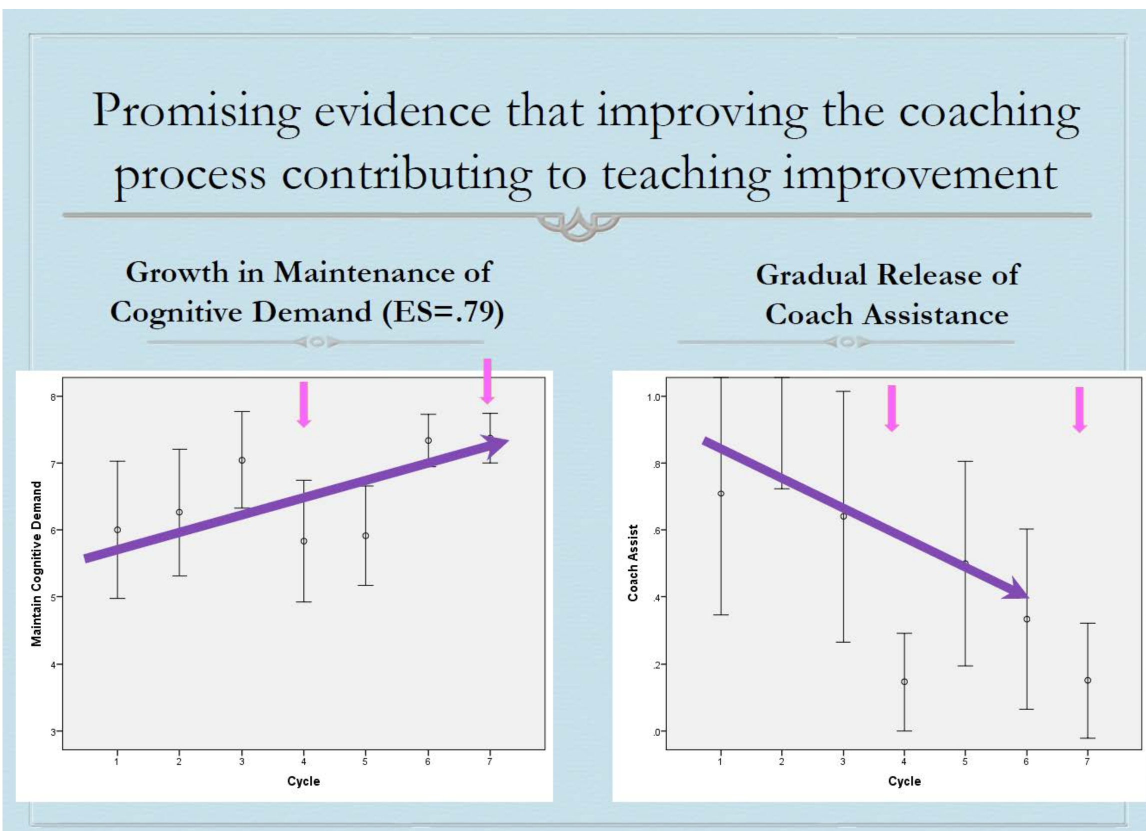


Figure 5. Coaching process contributes to teaching improvement.

As a mini-detour, our ongoing analytic work suggests that our work to improve the coaching process is contributing to improved teaching. In our network, we see from left to right on the left graph in Figure 5 that the average score on our teaching measure, which is maintenance of cognitive demand, improved greatly across the two years, and you also see the error bars are much smaller on the right. We're seeing both improvement and reduction in variability in teaching. And that's happening as coaches were also gradually releasing responsibility for instruction to teachers. In the beginning, there was lots of coach intervention during the lesson, and over time, teachers were doing it fairly independently. We're excited about that. We're in a quasi-experimental phase of our study now and keep your fingers crossed. We also have evidence, though, that those rigor factors in coaching are predicting gains in teaching. And I won't go too deeply into that, but it's again testing our working theories and finding some strong evidence.

While the core process improvement related to elaborating the coaching cycle did not include coaches running individual PDSA cycles, we taught coaches to use their own disciplined inquiry cycles to overcome the implementation challenges they encountered when trying to use our coaching model in diverse local contexts. One of our coaches, Holly Pillow, is a coach in two elementary schools in her small rural district in Tennessee. She's the only coach at the elementary level, and she finds herself in a district where administrators are really stretched then, both at the school and district level. So as a coach, rather than having enough time to work one-on-one and in small groups with teachers, she found she was getting pulled out all the time to run the testing program, to step in for absent teachers, etc. So Holly did a series of PDSA cycles to learn how to protect time for coaching. In the first, she introduced a new routine where she created a shared calendar and said where she was going to be, who she was going to be working with, and then at first she found nobody looked at it. But through a series of cycles, she found a way to reliably get administrators to respect that her primary role was to work with teachers and to look at that calendar before asking her to do an alternate task.

To summarize my reflections on the technical components of NICs, PDSAs can be an important tool but we need to think strategically about how they are used and take a broader perspective on the diversity of approaches that can contribute to continuous practice improvement. I'll transition to talking about the social structure or the social architecture of an NIC. My reflection about the social side is that networks need to nurture social connection, norms, and identities when growing and sustaining a professional learning community. We tend to focus in on the technical side of improvement, but NICs are organizations composed of people and the human and social side of what we're trying to do is complex. We've been trying to study and learn more about this social side. I'll talk about social connections, norms, and identities through our NIC development framework, and I invite you to reflect on your work and networks as I'm talking through these dimensions.

I'm blurring out the technical core now and focusing first on this first outer ring, cultivating the network's social organization, and we think there are four key components of that that are shown in yellow. The first is: it's important to consider the membership that you are building in your network to ensure that you're drawing the diverse pools of expertise and authority necessary to drive practical improvement. In the Tennessee Early Literacy Network, we see traditional authority structures represented in the inclusion of the state Department of Education, regional offices which are the arms of the state, then districts and schools within districts. But the network is also being strategic about bringing in expertise by hiring new positions for the hub in the Tennessee Department of Ed and contracting with the Carnegie Foundation for the Advancement of Teaching to build expertise in areas such as improvement science, analytic capacity, literacy, and literacy teaching. Another strategy they used besides hiring and contracting with partners is bringing in an expert convening on literacy to make sure that their working theory of improvement really reflected the best research knowledge in the field.

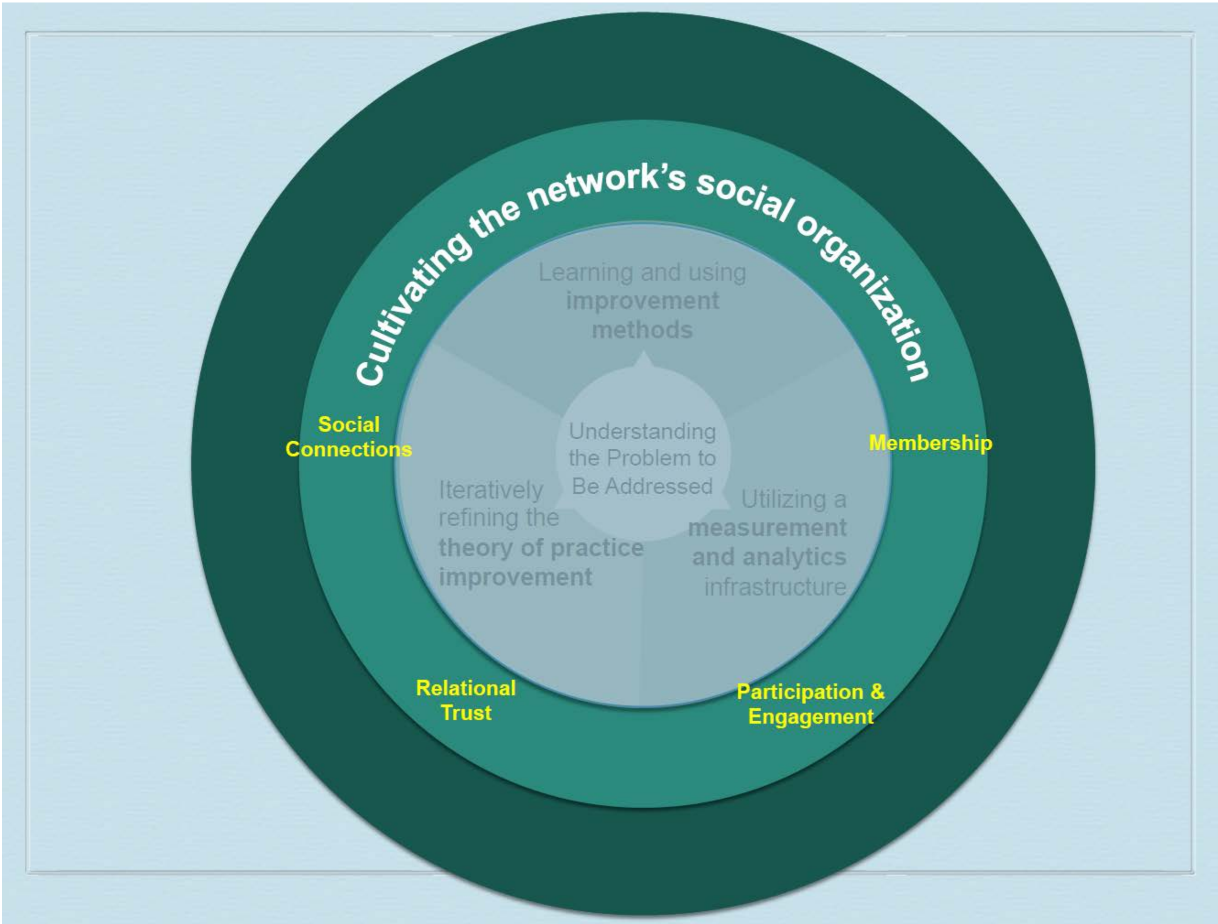


Figure 6. NIC social organization.

A second component of the NIC social organization is the participation and engagement structures. Once you have your membership, what are you going to do with them? How are you going to engage people in improvement work? And we believe that a functional NIC has participation structures in place that present a range of types of participation and allow for different levels of engagement. We can't expect that everyone is going to devote their whole life to our networks, because one of the challenges is, these are voluntary organizations. People have other day jobs and so we're trying to get them to do something on the side, but think about it as core to their work. For example, in the Better Math Teaching Network, the network of algebra teachers in New England I'm working with that's trying to improve student engagement, the network has generated a series of participation structures to promote teacher engagement. There are quarterly face-to-face meetings where teachers have an opportunity to learn new content, to learn improvement science methods, to build communities face-to-face; we do think face-to-face is very important. But then they meet in virtual groups where they're working with other teachers and they're addressing one driver or one component of the working theory of improvement. And they're meeting bi-weekly to plan and reflect on their inquiry cycles. And then the network is trying to provide opportunities and a structure for more informal interactions through things like listservs and a curated Google Drive system where teachers can post resources and raise questions, so multiple points of entry or participation for network members.

A third component of this social organization is the social connection, so we've got the people, we've got them doing things, and now we're hoping to build social connections in the network, working together in productive collaborative ways. We think that in a mature NIC, we should see strong connections among members working on particular strands of work, like affinity groups working around a primary or secondary driver. In addition, we think that we optimally want to build, albeit probably not as strong, weaker connections that span different organizations so that everyone has an opportunity at some level to learn what others are learning. In our TELN developmental evaluation, we've been tracking the emergence of social connections using social network analysis. These network maps represent the commenting behavior of network members in a network blog where members engage in virtual discussion to try to build this shared understanding of the problem of practice. This is also where they were posting those journey maps that I mentioned earlier. We tracked who was commenting on whose posts, and the dots represent network members, and they're color-coded to show--the blue are from the hub or at this point the initiation team, the pink and yellow are the two different regions of the state involved in the work, so they're--at this time, these were district leads involved in the network.

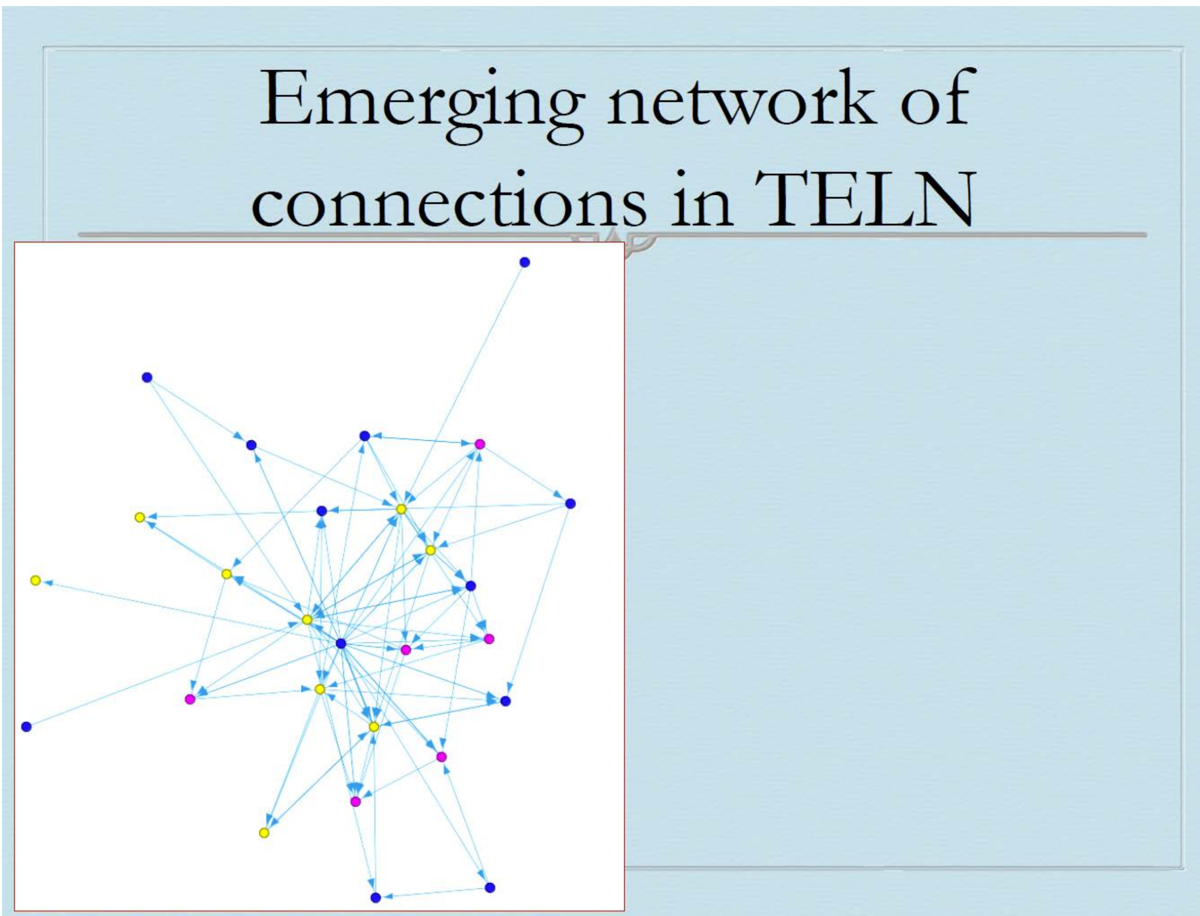


Figure 7. Emerging network connections.

In this early stage, (see Figure 7), many of the connections are between network members and one particular person at the center of the network map, who happened to be a staff member at Carnegie who was kind of facilitating the blog. So not surprising that a lot of the commenting was back to that central person. You also notice that the pink dots tend to comment on pink dots and the yellow dots tend to comment on yellow dots, meaning that there was not much cross-regional exchange at this point. It was heavily mediated by the network hub. For example, I might comment on somebody I know, but not some new person in the network. Approximately three months later, we repeated these analyses and started seeing changes in network connections that were aligning with our theory. We saw increased connections overall across the regions (see Figure 8).

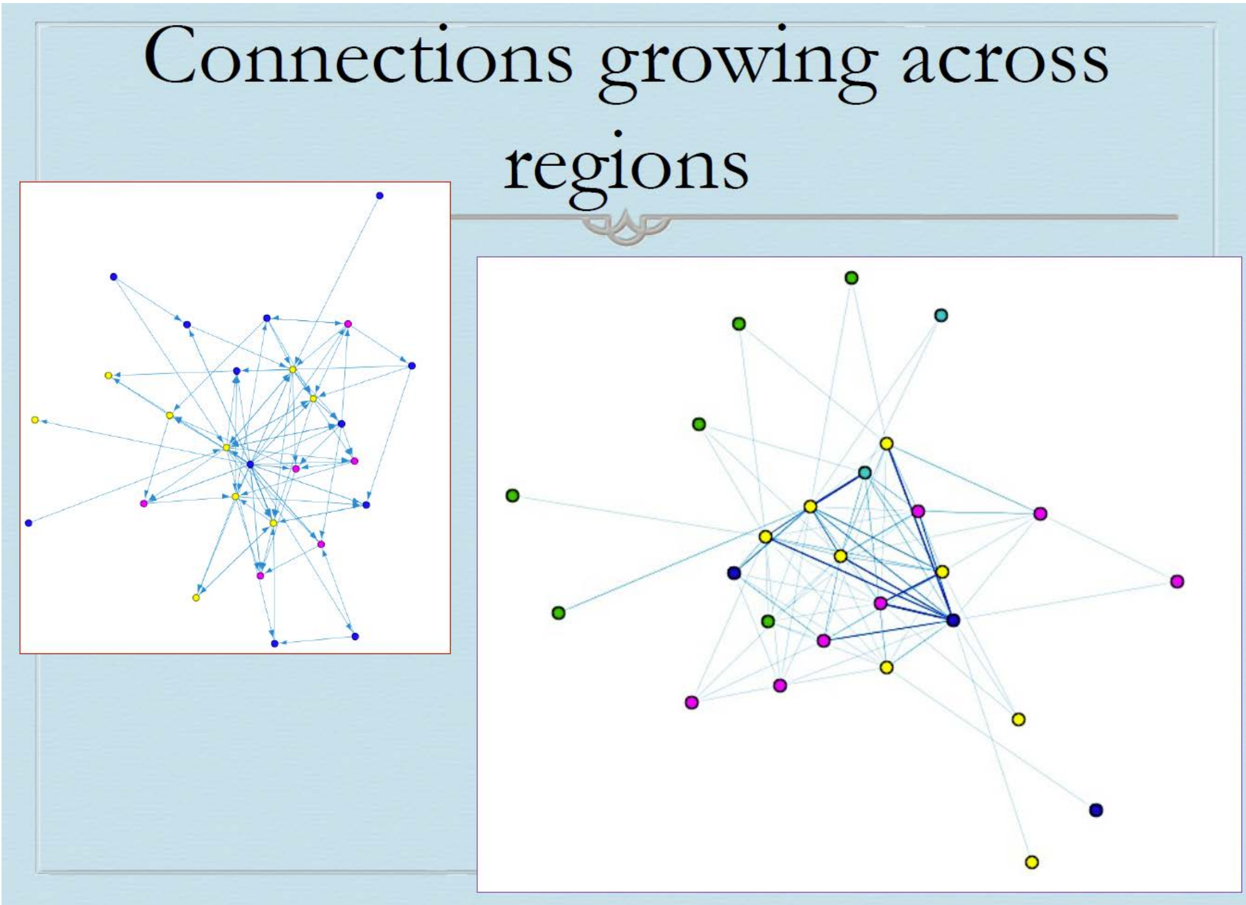


Figure 8. Connections grow across regions.

Educators were interacting with and looking to colleagues in other regions to deepen their understanding of the literacy problem. We saw emerging leadership, so more blue dots became more central, more members of the hub. And in addition, we saw several people from the regions, these district leads, now starting to occupy more central positions, meaning they are taking on some emerging leadership. And overall, there's just many more connections in the network. This is one way in our developmental evaluations that we're trying to look at how social connections are emerging in networks.

To conclude, I'm going to take you through a few of my reflections on the norms and identities that people need to develop in NICs.

Again, this is the outer circle in our framework, and again, there are four components of that. We think it's critical that participating members in NIC start to exemplify what we call an "evidence-based culture." This includes members feeling safe sharing data about their practice, their successes and what's not going well, and engaging in critical conversations, and members actively seeking out others in the network who are having successes through data or evidence. And finally, promising or successful change ideas are being drawn from what the field knows, from research evidence. One of the things that we noticed early on is that as we are empowering educators to be agents of change and agents of learning, sometimes we're seeing a disconnect between what we already know as a field, so they are generating ideas that we may have figured out to some extent in the research community, and it's about bringing those two ideas together so that people are not figuring out stuff that we kind of, in some ways, already know.

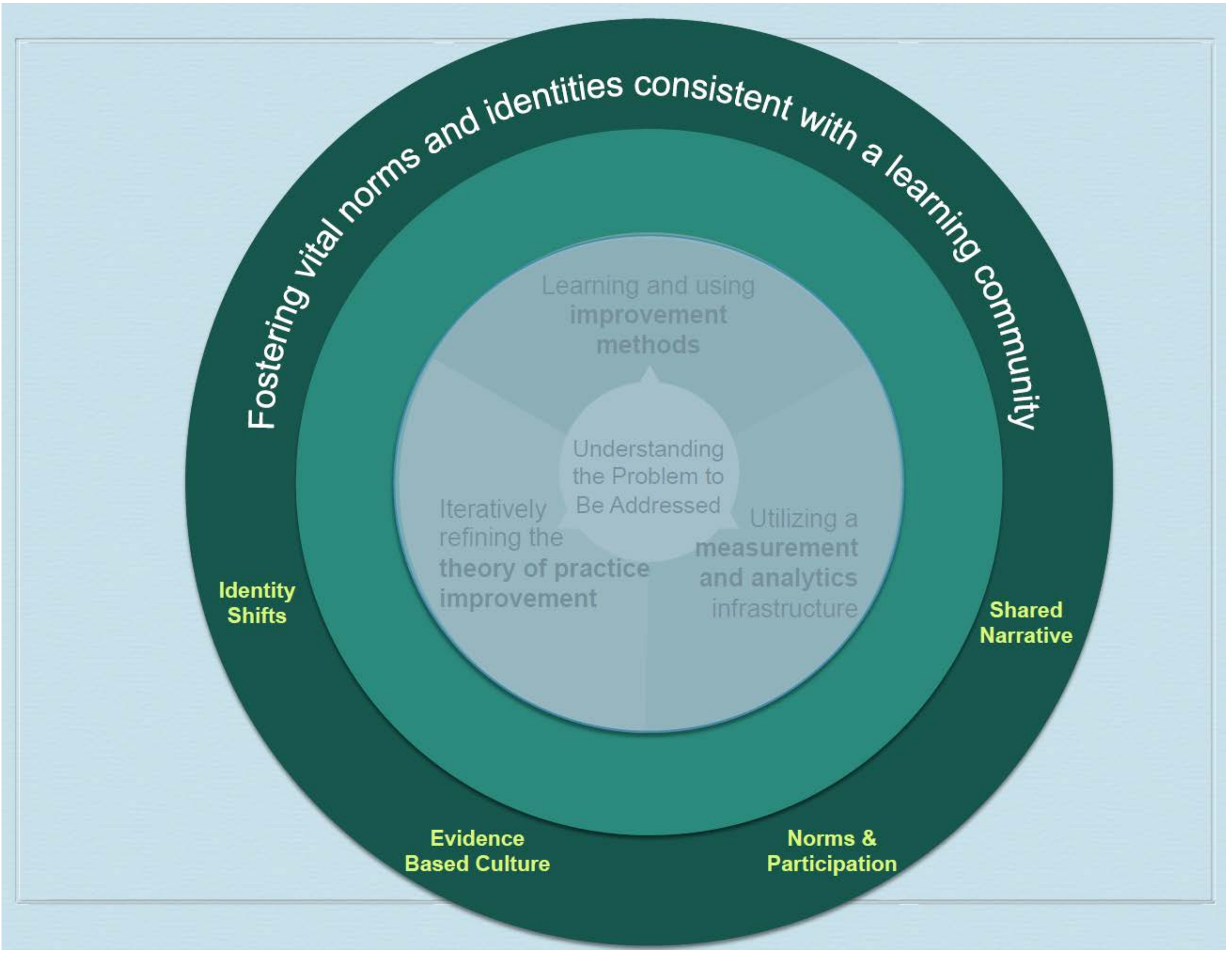


Figure 9. Learning community norms and identities.

We've developed a survey and we're trying to track the emergence of an evidence-based culture through it. In Figure 10, you can see a couple items from the survey, and the two different colored bars represent the two different networks that have engaged in the survey so far. One of the things that's interesting is that for one of the items, we looked to existing research to inform our improvement work. The respondents in the one network were a lot less likely to endorse that idea, and this was a critical insight that's helped the hub think about reshaping some of their engagement strategies, participation structures, so that we can ensure to get some of that research-based evidence into the work.

Next, this notion of identity shifts. We're looking to see that NIC members exhibit a "we" perspective, that they start to think about the collective rather than just to try to improve their own individual practice. So how do we build a commitment to the network that helps to sustain their engagement by identifying with it as a collective? We're also trying to get members of the network to make particular identity shifts. In the case of educators, it's often having them think about themselves as producers of knowledge. For researchers, it's about thinking about having accountability for practice and outcomes, so important identity shifts.

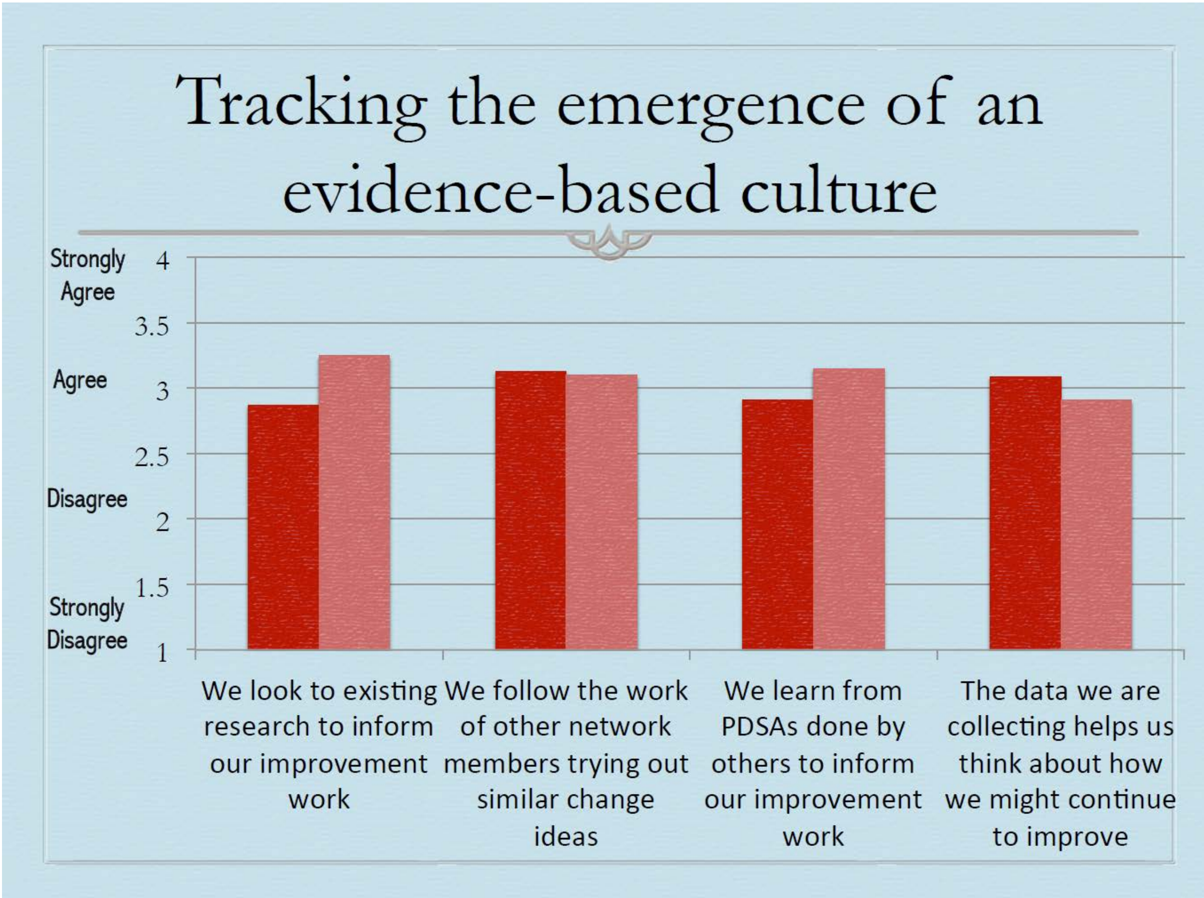


Figure 10. Emergence of an evidence-based culture.

Here's data from another survey item (see Figure 11). In this case, we were asking members of the network to reflect on the extent to which the work in the network is a core part of their work. And here you see we're looking at patterns in the data by role groups and seeing some interesting differences. For example, regional staff were less likely to say that it's a core part of their work. This is an insight that is helping us see the strong relationship between identity and the way that we design participation structures in the networks. These regional staff members didn't have a central role early on and were kind of struggling to find their way, so not surprisingly, they're not feeling as connected. We're also seeing differences between school teams in our two regions, one region expressed lower identification with the collective of the network over all. And that gives us a theme, to examine through other ways, so we'll be planning some follow up interviews, to try and understand more about why there's those differences.

A third component of fostering norms and identities is the development of a shared narrative. A shared narrative of improvement is evident in talk and documentation, and we think of a shared narrative as including personal stories of why people are involved in a network, a collective story about what we're trying to accomplish together, and urgency for attending to the problem. Something else we track in our developmental evaluation work, in the early literacy network we did interviews early on with district leads, and it was interesting to see a converging narrative about what they value in the network.

Finally, our fourth component of this area is norms of participation. And again, this resonates with some of the identity shifts that we are hoping to see, that network members take on this commitment to disciplined inquiry and their role of knowledge generators, and then there's other ideas about common work and documenting and sharing our knowledge. So that's our NIC development framework. I haven't talked much about leadership. That's for another day, but we see the work of the hub and other distributed network leaders as driving these other domains toward the scientific and professional learning communities.

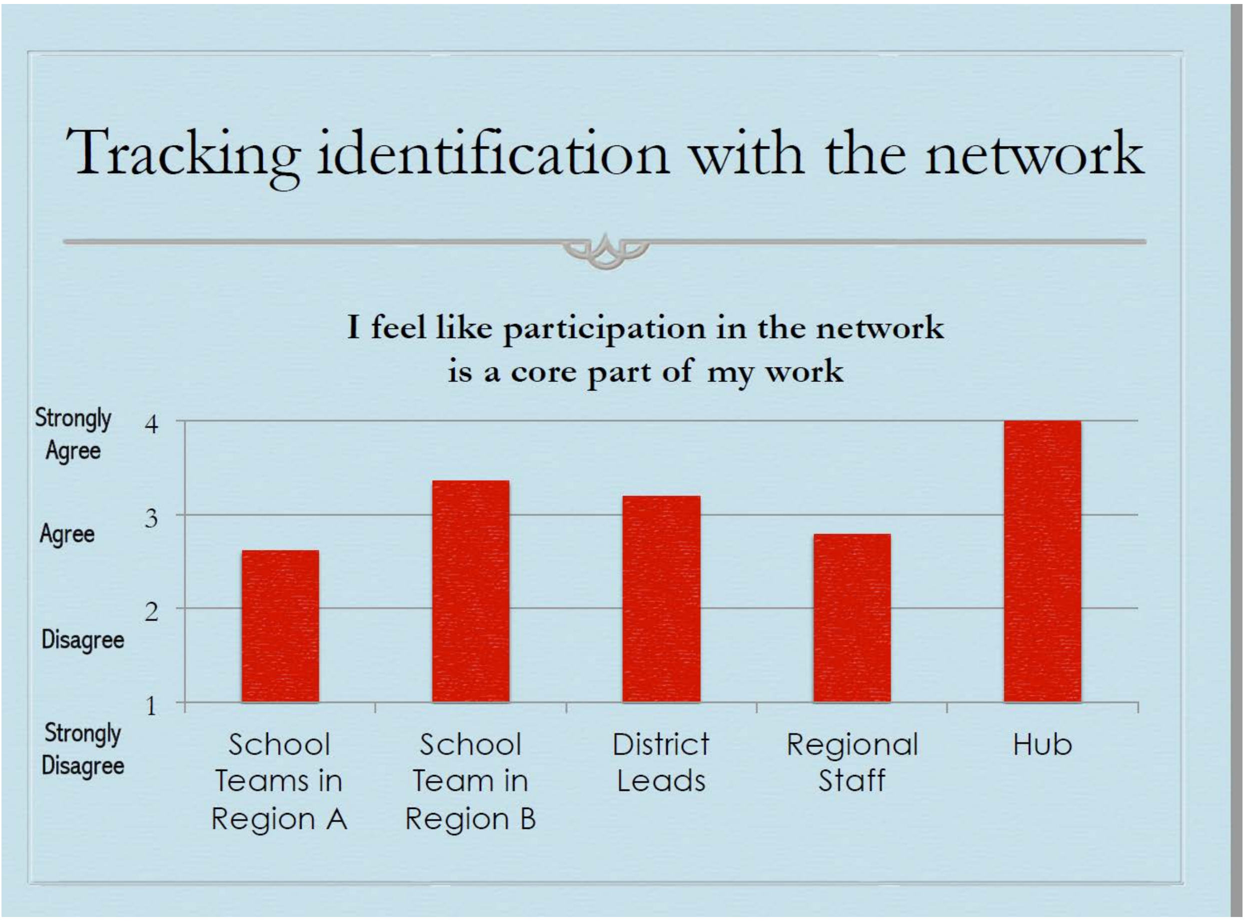


Figure 11. Network identification.

Our work to understand and support NIC development is ongoing and we're generating developmental trajectories of various NICs in the field and trying to test our theory by looking at how these networks unfold. And we're also generating tools for network leaders and developmental evaluators, like surveys to track network health and a self-assessment tool that network leaders can use. I thought over these four reflections, and in conclusion, what are the implications for the MTE-Partnership? In many ways, I think what you're doing is strongly resonant with these reflections. So, my first point is keep doing what you're doing. You may want to utilize, though, this NIC development framework as a tool for reflection on the ongoing work to catalyze your networks. And as you're doing that, remember to keep utilizing a range of improvement methods, such as understanding the problem, a broad sense of inquiry, not just the small improvement cycles. And finally, keep in mind the nurturing social connections, norms, and identities by paying attention to member experiences in the network. It's a key part of sustaining this work.

PANEL TALKS

Addressing Equity within the Clinical Research Action Cluster: Establishing a Common Lens through which to Examine Mathematics Lessons

Mark W. Ellis, California State University, Fullerton, mellis@fullerton.edu

The Clinical Research Action Cluster (RAC) within the Mathematics Teacher Education Partnership (MTE-Partnership) has been examining challenges related to the clinical fieldwork and associated methods coursework of secondary mathematics teacher candidates (TCs). The primary concern among RAC members—university faculty and school district partners—is the mismatch between research-based practices of mathematics education that foster engagement and success among a diverse range of students—something central to our preparation programs and embedded in AMTE's *Standards for Preparing Teachers of Mathematics*—and the actual practices TCs encounter in their field placements that are often more reflective of procedurally-oriented 20th-century mathematics teaching. Since fieldwork experiences have the most influence on TCs' future professional practices (Wilson, Floden, & Ferrini-Mundy, 2001), we have worked to identify reasons for this mismatch and to implement strategies that address these.

Discussions among RAC members led to the realization of the importance of a) articulating between university and school district partners a mutually agreed upon common vision of high-quality secondary mathematics lessons and b) establishing a common lens through which to examine mathematics lessons as a measure of the degree to which this vision is being enacted. The *Common Core State Standards for Mathematics* (and other similar standards documents) have done well to emphasize mathematics as more than content standards, identifying the eight standards for mathematical practice (SMPs) as central to students' processes of mathematical reasoning and sense making. We agreed that our vision of high-quality secondary mathematics lessons would be grounded in student engagement in the SMPs. NCTM's (2014) eight research-based Mathematics Teaching Practices (MTPs) delineate specific professional practices known to promote learning for all students that is aligned with new college and career ready content standards, so we came to agree that becoming knowledgeable about and proficient with the MTPs must be at the core of teacher preparation coursework and clinical experiences. This is reflected in the Clinical RAC Aim Statement: "During student teaching Teacher Candidates (TCs) will use each of the eight Mathematics Teaching Practices at least once a week during full time teaching."

However, within our partner school districts there are not enough mentor teachers (MTs) at the secondary mathematics level who routinely engage their students in the SMPs and would be prepared to foster the growth of teacher candidates in their use of the MTPs. Conversations with school-district partner leaders indicated that this was the result of a) long-standing beliefs among MTs about how mathematics is taught; b) concerns among MTs about students' readiness or willingness to engage in mathematical reasoning and sense making; and c) insufficient opportunities for MTs to learn strategies for engaging students in the SMPs through implementation of the MTPs. As a result, we came to see the preparation of each new teacher of secondary mathematics as an opportunity to disrupt long-standing teaching practices that contribute to inequities in learning outcomes. We acknowledged it was our collective responsibility (university teacher preparation faculty and school district partners) to ensure that requirements for student teaching and feedback during student teaching emphasize the responsibility of TCs to advance mathematics learning of all students through routine engagement

Smith, W. M., Lawler, B. R., Bowers, J., & Augustyn, L. (Eds.). (2017). *Proceedings of the sixth annual Mathematics Teacher Education Partnership conference*. Washington, DC: Association of Public and Land-grant Universities.

in the SMPs.

One tool our RAC has begun to utilize that both reflects our shared vision of high-quality secondary mathematics teaching and serves as a measure of the extent to which such practices might be occurring in field placement classrooms is the *Mathematics Observation Protocol for Practices* (MCOP^2; Gleason, J., Livers, S.D., & Zelkowski, J., 2015). Built from a rigorous process of drawing on research and multiple rounds of seeking practitioner input, the MCOP^2 has both strong psychometric properties and strong validity. The 16 indicators fall into two factors—student engagement (SE) and teacher facilitation (TF)—each of which have nine items (with two items loading on both SE and TF). With respect to equity, three of the SE items include language about the proportion of students productively engaged in the mathematical discourse community:

1. There was a high proportion of students talking related to mathematics.
2. There was a climate of respect for what others had to say.
3. Students were involved in the communication of their ideas to others (peer to peer).

The descriptions for these items reference concerns with equitable participation and the teacher's role in creating a learning environment in which all students have a voice and are given mathematical authority. The specific indicators include quantitative estimates of the proportion of students meaningfully participating in mathematical discourse and sharing ideas. While far from a perfect gauge, it is fair to say that there cannot be equity without first equality of participation.

After identifying the MCOP^2 as a tool that would provide feedback about our progress toward the aims of the Clinical RAC, some colleagues and I at California State University, Fullerton designed a training on the use of the MCOP^2. We felt in order to really understand where it came from time had to be devoted to examining the rationale for changing what we have been doing in mathematics classrooms in the United States since the early 1900s. Part of the training calls into question 20th-century schooling practices, including beliefs about mathematics and beliefs about ability, that led to a) the system of tracking that denies so many students access to meaningful learning and b) the method of teaching mathematics as rule-following rather than sense-making. We share that this system reflects social biases and misconceptions that were much more pronounced at the beginning of the last century but whose impact is seen in practices of schooling throughout the United States. We then talk about current research that has informed the MCOP^2 and engage in watching video clips of mathematics lessons and determining ratings for each of the nine MCOP^2 items. The spirited discussions that arise help participants to clarify what is meant by commonly used terms such as "problem solving" and "engagement."

Having done this training with over 100 teachers, faculty, and supervisors within teacher credential programs at CSU Fullerton, we have received feedback indicating it has helped them to think more deeply about what it looks like to engage all students in learning mathematics. Our programs place TCs in diverse school districts in southern California in which historic student outcomes in mathematics mirror national trends with large differences in achievement that correlate with demographic markers of ethnic, SES, and linguistic background. We believe that the MCOP^2's focus on students' equitable engagement in SMPs offers a productive avenue through which to bring attention to inequities in participation that are otherwise ignored (and accepted as the norm). While in the early stages of implementation, there are indications the use of MCOP^2 to examine mathematics lessons is reshaping conversations about planning and instructional practices that have the potential to impact students' experiences in mathematics classrooms and their learning outcomes.

The questions we will be exploring as our implementation of the MCOP^2 continues include:

- How might we use MCOP^2 items to inform candidates' lesson planning?

- How might we strengthen the quality of evidence that people are using for their MCOP^2 ratings?
- And how might the MCOP^2 help us to open doors to conversations with district partners about addressing long-standing disparities in student outcomes in mathematics?

References

Gleason, J., Livers, S.D., & Zelkowski, J. (2015). Mathematics classroom observation protocol for practices: Descriptors manual. Retrieved from http://jgleason.people.ua.edu/mcop2.html.

National Council of Teachers of Mathematics (2014). *Principles to actions: Ensuring mathematical success for all*. Reston, VA: Author.

Wilson, S. M., Floden, R. E., & Ferrrini-Mundy, J. (2001). *Teacher preparation research: Current knowledge, gaps, and recommendations.* Seattle, WA: Center for the Study of Teaching and Policy.

Equity Panel: Matt Voigt

Matt Voigt, San Diego State University, mkvoigt@gmail.com

One of the reasons I'm up here talking is not because I'm an expert in equity; I don't claim to be. But, I have a vested interest in equity and in active learning from both personal experience as a first-generation college student and as a queer student. Overcoming those obstacles has provided unique lessons for me, as well as being invested in active learning techniques. I want to share with you the research that we've been doing as part of the SEMINAL project. If you're not familiar with the general project, it's an NSF-funded project looking at how math departments incorporate active learning in Pre-Calculus to Calculus II. We have three pillars of active learning: deep engagement in mathematical reasoning, peer-to-peer interactions, and instructor inquiry into student thinking. That is how we're broadly defining active learning. And how we're conceiving, or, how I'm conceiving of equity, is I'm reusing this often-shared image, below.

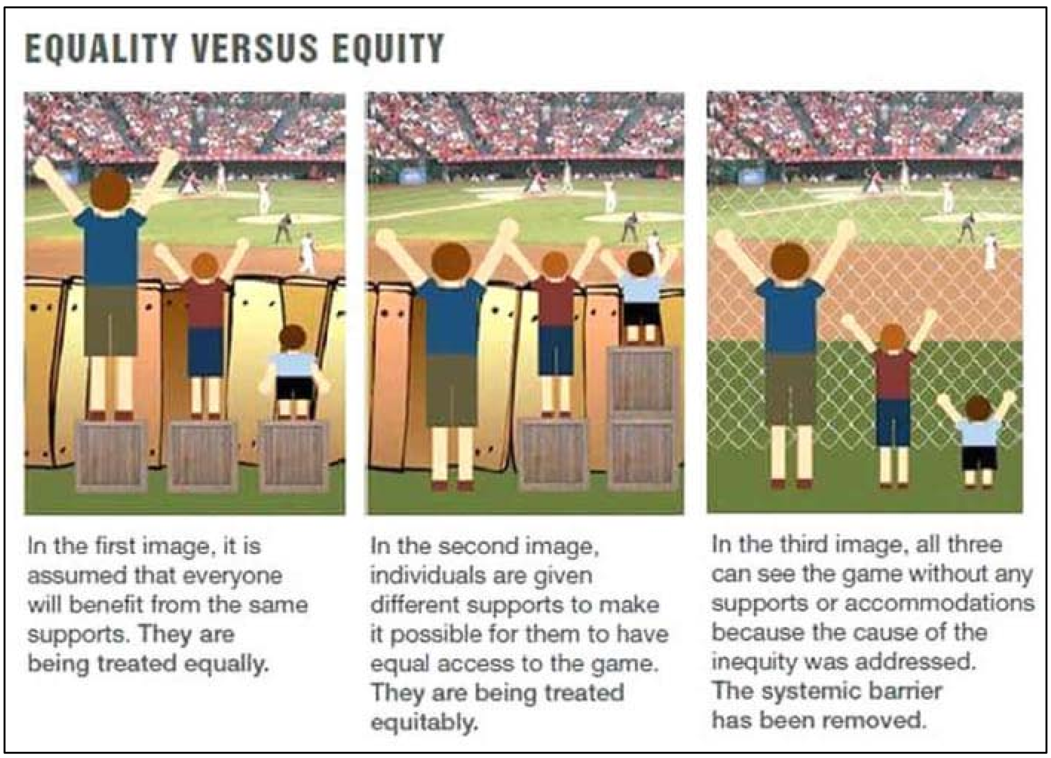


Figure 1. Visual depiction of the difference between equality and equity.

It's a pretty common image, but I think it helps us frame how we think about teaching. We can't just teach the same to all of our students, because it's not going to lead to equal outcomes. We have to privilege certain students, we have to give voice to other students, and empower students who are extraordinarily marginalized, and that's demonstrated in this second picture. And I think the third picture, with that chain link fence, says we need to remove systemic barriers that are prohibiting students from achieving.

How are we defining success? How are we defining what types of classrooms we have? Rethinking those is all part of how we're thinking about equity and trying to challenge those notions. There's been some research on the intersection of equity and active learning. The Freeman report (Freeman et. al., 2014) basically came out and said "yes, active learning is great, leads to student success." And I think we buy that, because we have a RAC invested in active learning. But that report was, basically, general. It didn't identify any types of students. It just said, overall, if we lump all students together, there are performance increases. So in a larger sense, we had investigations saying that women basically have an equal playing field now when we use active learning (Laursen, Hassi, Kogan, & Weston, 2014). Indigo-Esmonde (2009) has really shown that cooperative learning can help with identity development. There's some indication that active learning does promote equity, but not to the point where I think people are assuming that it's just a standard. We can't just say active learning is going to solve equity, because it's not.

As part of the SEMINAL project, we said, "OK, we're going to go into these classrooms, and we're going to do observations. How can we observe equity?" We wanted to observe live, real-time, active learning, so we decided to use the MCOP^2 (Gleason, Livers, & Zelkowski, 2017). We also said, "We need a little few additions to those, just pile them up, see what maybe we aren't observing through the MCOP^2." One of the things we added was making sure that we have that the instructor has high expectations for achievement. We know from Robert Moses that having high expectations of students is critical to students succeeding. We have to believe in the students if we really think that they're going to succeed. We had a scale for expectations and high achievement, and also wanted to know, just overall, what percentage of students were participating in the discussions. And we really had to account for large lectures of 150 students all the way down to 30 students in a discussion section. We had to be adaptable for what we were doing, so they were just broad. We wanted to get a sense for: what could we observe equitably?

We also asked, "What are equitable practices that teachers can do, that would be observable?" We sort of take it as a standard that equity doesn't just happen, doesn't have to be actual actions that are occurring in the classroom to achieve it. We drew an indicator, culled literature, and came up with some observable practices. Teachers calling students by name promotes equity and promotes achievement. Using randomized response strategies, since everyone has implicit bias of whom they call on, whom they're privileging in their classroom, then using a computer to remove some of that bias, to randomly call on students, is a technique to eliminate some of that bias. Using heritage language, acknowledging students' current knowledge before instruction, is getting those students privilege to engage in the discussion, since you are acknowledging that they are there, they have something to contribute, and then moving forward from that point.

We also focus a lot on mathematics. We want to build mathematics, but also team-building, social team-building. For first-generation college students, for commuter students, not having a sense of support among their peers is detrimental. So, are teachers doing activities that promote team-building? Using cooperative groups? And are teachers using and encouraging positive self-talk? So if somebody couldn't come to a right answer, it's "wow, look at that method that you tried. You know that doesn't work. That's great. So now what other methods do we know about?" Those are actions or things that can encourage equity. It leads to the observation protocol to say "OK, how many of these were occurring and which ones were occurring?" And then after this, we're going to kind of analyze "well, can they be grouped? Which ones are actually occurring in university Pre-Calculus to Calculus II sections?"

- Welcomes **students by name** as they enter the classroom or calls on each student by name in class.
- Uses **randomized response strategies** for calling on students (e.g. rolling dice, computer generated roster name)
- Uses student's "heritage" language (e.g. Spanish, Chinese, etc.)
- Identifies student's **current knowledge before instruction**
- Uses students' real-life experiences to connect school learning to students' lives
- Circulates around student work areas to be close to all students
- Instructional materials, and other visuals used in the classroom reflect the racial, ethnic, and cultural backgrounds represented by students
- Uses class building and **teambuilding activities** to promote peer support
- **Structures heterogeneous and cooperative groups** for learning (i.e. random groups, etc.)
- Acknowledges all students' comments, responses, questions, and contributions.
- Allows students to revise work based on teacher feedback
- Explains to students the importance of **positive self-talk**

Figure 2. List of observable equitable classroom practices.

Then we asked, "How can we measure equity in these courses?" We are administering surveys to all of the students and the instructors. First, we drew on the scale from the WHIC, which is "what's happening in the classroom?" and we modified that to rate "do you think you're getting as much opportunity to answer questions in class at the same as other students, less than other students, or more than other students (see Figure 3)"? There's self-identification for how much of a part of the community they are and how much opportunity they have in relation to their peer. We added this sort of component largely based on equity. And we also wanted to triangulate these observations that we were doing (see Figure 4). We're going in, we're observing, we're keeping track of all these, and then we want to say, "What do the students actually think?" We asked the students: is there a sense of community? Do you think your instructor knows your name? And we added this scale, because these are important elements to whether a student actually feels that there's a sense of community.

	Less than other students	The same as other students	More than other students
How much opportunity do you get to answer questions in class?			
How much attention does the instructor give to your questions?			
How much help do you get from the instructor?			
How much encouragement do you receive from the instructor?			
How much opportunity do you get to contribute to class discussions?			
How much praise does your work receive?			

Figure 3. Adapted student survey questions from WIHIC related to perceived equity.

	Does not Occur	Minimally	Somewhat	Mostly	Very Much
There is a sense of community among students in this class					
The instructor calls on a wide range of students when asking questions in class					
The instructor knows my name					
The instructor adjusts teaching based upon what the class understands and does not understand.					
The instructor explains concepts in this class in a variety of ways					

Figure 4: Student descriptions of equitable practices in classrooms.

We developed the demographics section of our survey next, which took a very long time, just in terms of getting the right wording. I'll just go through a few points. If you're going to do some survey work, don't use the term "other," just put "not listed." We're going to allow multiple sections, even in gender, even in race, so that people can identify whatever they identify with. If you're including gender, have a gender-fluid or non-binary option. Race/ethnicity was hard for us to identify what sort of continuum we wanted, so we based it off the U.S. Census but then expanded that based on our pilot data. For example, we know Middle Eastern is not something that is on the census data, but in our pilots people were putting that quite frequently, so we decided that we needed to include that. Sexual orientation we included, partly because it's part of my research area, but we got pushback from the IRB saying, "why are you asking for this information?" And we said this is as relevant, just as much as race and gender are and you're not pushing back on that. It's accounting for different student identities. What are other populations may we be missing? First-generation students, student athletes?

Here is our very preliminary analysis. We have a lot more work to do, but these are some of the original things that have been coming out of these reports. There are 3,000 students who have filled out our survey across courses that are always in active learning. So, we think "OK, these are generally good courses. We should be seeing some equitable achievement." But what we see is that women are reporting that, in comparison to their peers, it's less equitable. They're getting less time, less feedback from the instructor, so that's troubling. But, they are recording that they work more in small groups so that may mean active learning is one component to getting students to engage. On the belief that the instructor calls on a wide range of students, women report that less than non-women in this class. And then women also statistically miss more class, which is not surprising if you're reporting that "I don't feel as equitable treatment and I'm not enjoying this class." You're going to be less likely to want to go. Again, queer students anticipate lower grades and report less of a sense of community. If we look at Hispanic or Latin students, overall, again, they report less equitable classroom experiences. If we look at white students, they report a greater sense of community among them. They believe their instructor knows their name. They report missing less class. And then if we look at special populations, commuter students and first-generation students report overall less equitable classroom experiences, while international students report a greater sense of equitable treatments.

We want to do a deeper analysis and then look at multiple-marginalized. What are the experiences of women of color, what are the experiences of queer black men? These are issues that we want to engage in, not just at a general level. Sandra Larsen's work is saying "Women do better in active learning" and we want to ask which women? It's about delving down into the multiple identities and then seeing if the reports show any correlation between what the instructor is reporting that they do in the classroom and what the students and the different populations of students also report.

References

Esmonde, I. (2009). Ideas and identities: Supporting equity in cooperative mathematics learning. *Review of Educational Research*, 79(2), 1008-1043.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences,* 111(23), 8410-8415.

Gleason, J., Livers, S., & Zelkowski, J. (2017). Mathematics Classroom Observation Protocol for Practices ($MCOP^2$): A validation study. *Investigations in Mathematics Learning, 9.* Retrieved from: http://dx.doi.org/10.1080/19477503.2017.1308697

Laursen, S. L., Hassi, M. L., Kogan, M., & Weston, T. J. (2014). Benefits for women and men of inquiry-based learning in college mathematics: A multi-institution study. *Journal for Research in Mathematics Education*, *45*(4), 406-418.

Equity Panel: Maria Fernandez

Maria Fernandez, Florida International University, mfernan@fiu.edu

I am here to talk about the program recruitment and retention Research Action Cluster (RAC), which was the previous MATH RAC, Marketing for Attracting Teacher Hopefuls. Part of the leadership team that was involved in what I'm going to be sharing today was Dana Franz and Julie McNamara and then Ed Dickey. They asked us to think about what we had been doing, what were the challenges we had.

In the original MATH RAC, the recruitment target was just margin of error; there really wasn't a focus on diversity on the recruitment target itself. When you look at the primary drivers, we had one out of four that was attracting and graduating diversity candidates. That's very broad and not well-defined, so that is part of the challenge we had in the original MATH RAC in terms of equity and diversity. We were trying to just throw a large net out to try to increase enrollment. We weren't focusing as much on how many Hispanics, how many African-Americans, how many Native Americans, those kinds of things.

Another challenge was in collecting the data. There were logistical issues related to collecting data on race/ethnicity. When students are just being made aware of the program, how do you capture that? In sign-in sheets, are you always going to have the question, "What is your race/ethnicity?" When they call in and ask about the program, do we say "oh, what's your race/ethnicity?" No, so we had those struggles. Then there was concern that asking that question can make a negative impression. People asking, "well why are you asking me about my race/ethnicity?" Gender, too. And, you have the people who might think it's prejudiced.

The other challenge we had was defining "diverse"; how "diverse" was very broad across the different institutions, and we really hadn't pinned that down. We weren't focusing on the retention piece of retaining the teacher candidates from diverse backgrounds or from backgrounds related to our local needs. With the focus on diversity in the revised program for recruitment and retention, our recruitment target mentions, directly, "reflecting diversity targets of each program." We recognize that different programs are going to have different targets because of their local setting, their local context. We came up with three out of five primary drivers that directly address the local demographics and the diverse communities, so more targeted thinking about what "diversity" means. Like the AMTE Standards for teacher preparations, saying "You need to be more direct about it. You need to infuse it throughout. It can't just be an add-on, the idea of diversity and equity." Those primary drivers then influenced the change ideas. The possible change ideas are targeting the issue of diversity and how do we bring in more students that meet the demographics of the students they're going to be teaching, of the students in our locale. Because we were more direct about it at the recruitment target with the new reboot of the RAC, then that fed into more direct targeting in the drivers, which then led to more direct targeting for us in particular for this RAC in the change ideas. Thank you.

Equity Panel: STRIDES

Joleigh Honey, Utah State MTE-Partnership, Utah State Board of Education, joleigh.honey@schools.utah.gov
Frederick Uy, CSU-MTE-Partnership, California State University, Los Angeles, fuy@calstatela.edu

Overview

Joleigh Honey: I am a first-generation college graduate. My mom was 15 years old when she became pregnant, 16 when she gave birth to me. I grew up with "generational poverty." I have three brothers and yet I am the only child in my family to graduate from high school. I am a woman who experiences white privilege. My mission: promote equitable math opportunities by changing how people engage with and view mathematics.

Fred Uy: I am a male, lifelong learner of Asian descent. Staying with the stereotype, I do like mathematics. However, liking it came to me at a later date when I was a sophomore in high school. It was during this time that I was told by my teacher that there are other ways to arrive to the solution, if any, to a mathematical problem, and boy, that statement did light up the sky for me. I excelled the rest of high school, struggled in college, and shone again during graduate school. My mission: make students find mathematics useful and enjoyable.

1. *What are the equity issues/challenges that impact or relate to your RAC's work toward the Aim statement?*

   The equity challenges that relate to the STRIDES RAC for Recruitment include the following:

   - Prospective candidates not seeing themselves as mathematics teachers.
   - Not enough students with risk factors are supported/mentored in a way that allows them to identify as a math teacher.

   Additional issues and challenges for the STRIDES RAC include the following for new teachers:

   - New teachers may not be properly trained to understand equity issues and not be aware of how to properly differentiate to ensure all students are receiving high-quality instruction.
   - New teachers have many new things to take into consideration, and are often not aware of unconscious bias or recognize that students have a lot to offer, resulting in more direct instruction as opposed to focusing on student thinking and reasoning.
   - Often, students with risk factors are the ones placed in a "slower" track, which is also what the newest teachers are assigned to teach. This, ultimately, is an equity issue for both students as well as the new teacher.

2. *How is a focus on equity reflected in your RAC's work?*

   Support for teachers through:

   - Virtual networks to connect new teachers with positive, professional mentors
   - Professional organizations
   - Lesson studies
   - "10 minute chats" with mentors
   - Learning cycles
     - Mentor modeling teaching practices
     - Breaking down implementation of teaching practice
     - Rehearsal and reflection

- Repeat

3. *In what ways have you begun to collect data about these equity issues/challenges? What have you learned and what new questions have arisen?*

STRIDES RAC has created a survey for new teachers that include the following ideas:

- What is most important to them to be successful in their new role?
- What are the greatest challenges they face as new teachers?
- What type of support do they value/need/want?

Results of survey highlight the following:

- New teachers WANT and need support. There has to be a mechanism of support and interventions to keep them in the profession.
- Equity issue: New teachers often lack skills to help students overcome identity issues in mathematics and yet, we frequently place students and teachers who both need the most support together in a room.

Note: One of the unexpected results that the STRIDES group realized is that we explicitly must make known the need and importance of selecting and creating good mentors.

Equity Panel: Nicole M. Joseph

Nicole M. Joseph, Vanderbilt University, nicole.m.joseph@vanderbilt.edu

First, some of the things I say might make you uncomfortable. But, just like we push our students to take risks and to try to think differently, that's my hope for you all today; for all of us to think about some things in different kinds of ways and be open to challenging ourselves as scholars, as math educators, as human beings.

This conversation with the equity panel it also a conversation for all of us. I tried to read everything that I could about MTE-Partnership. One of the things I went to immediately was the mission statement, and it reads "MTE-Partnership aims to build a national dialogue around guiding principles for the preparation of mathematics teachers, promote partnerships among all sectors throughout the teacher development process, with a focus on promoting institutional change." I want the words institutional change to really sink. "Develop and coordinate a network, research, and critical--research and development agenda, serve as a clearinghouse for models, programs, and practices, and advocate for change at the university, state, and national levels." As I thought about that statement and I thought about this idea of transforming, one of the things I'd share with you all, as well as the entire committee here, is this notion of transformation. I'm wondering how we might be able to think about that in a more critical kind of way. Therefore, when I was reading the papers, some of my initial observations that I wanted to make immediately were the following: one, many of the panelists provided positionality statements. Positionality is important when you are doing equity work because it allows the reader or the audience to hear how you show up in the work. It was important to me when I read your statement "I'm a white, cisgender male with friends that are Asian." Positionality is important so that people can understand your assumptions and biases. All of us have them, assumptions and biases, and so I really appreciate that. The second thing was, these folks have done a lot of work in terms of time and labor and trying to create measures to measure equity. Why? Because they are very much aware of the context that we live in, that you have to always measure what it is that you care about if you want funding from the NSF, for example. They want to know: what are the outcomes? How do we know? Therefore, they have done a lot of work around that, which I want to commend them for. Overall, I got the sense that they are very much committed to equity in education and that is positive in my mind. I made a word cloud and I dumped all of their papers and slides into this program, and these words came up. What do you notice?

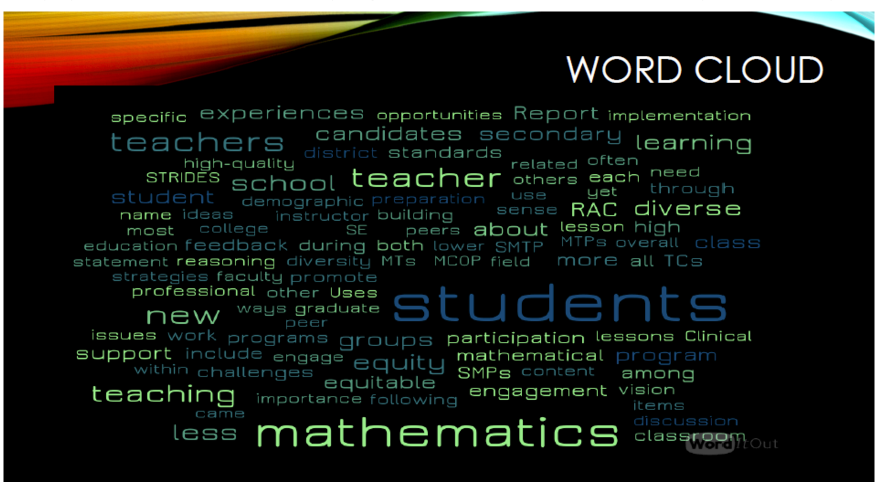


Figure 1. Word cloud from equity panelists.

Smith, W. M., Lawler, B. R., Bowers, J., & Augustyn, L. (Eds.). (2017). *Proceedings of the sixth annual Mathematics Teacher Education Partnership conference*. Washington, DC: Association of Public and Land-grant Universities.

Students really stands out. What else? Mathematics. Anything surprising?

(audience response) Equity is missing.

Equity's actually there, but it is really small. Any other observations? Well, agency is not necessarily there. Any other observations? Participation is small. Therefore, I just wanted us to see that visual and to think about that as we continue to do our work around math and equity. The charge of the panel is to answer these questions:

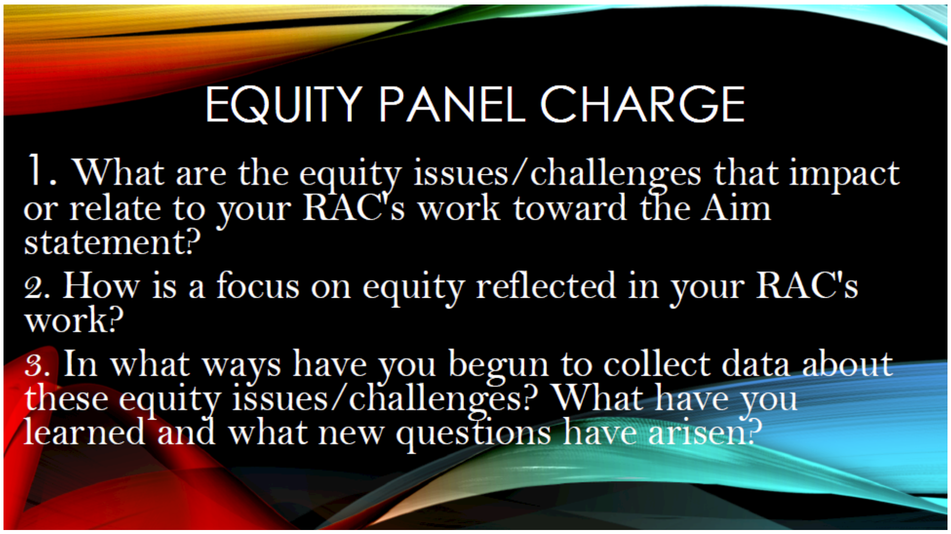


Figure 2. Charge for the Equity Panel.

Overall, what I noticed was that there are some issues. The issues that really showed up are around recruitment and around retention. My observation about question two was that diving deeper into conceptual bases and definitions of equity could really help illuminate more specifically how equity is being reflected in your RAC. My overall observation about question three is that although the authors do have the resources to measure challenges, having a more clear definition of equity, collectively, could lead to more targeted lessons learned.

As for recruitment, prospective teacher candidates don't really have a math identity. And the question is why? These are things that I just kind of want us to think about. They don't have a math identity. Why? Prospective teacher candidates of color are not interested in becoming math teachers. Why? Mathematics is not viewed as an attractive or worthwhile subject to teach. Why?

The next area is retention. Teachers are not staying in the field. We heard from someone earlier that teachers get burnt out, and these are things that we need to think about. New secondary math teachers do not understand equity issues at a deep level. It's just not enough to think "OK, I'm going to know the names of my students," for example. It needs to be at a deep level, and I'll go a little bit further as I get close to the end of my talk, kind of what that might look like. Because our students are tracked, and we have heard this now three or four times, new teachers usually get the low-tracked students, which can be perceived as the bad students. My challenge to us is to follow the path back. You need to know and read Jeannie Oaks' work. She has given us 30 years of empirical research around the challenges of tracking and how it is very negative for all students, even students that are in the advanced tracks. She said it starts at third grade, such as the yellow bird group, the blue canary, etc., and kids are not stupid. They know which track they are in. The other thing is, she problematizes the type of math instruction that happens in those low-level classrooms. You will not see Socratic Method around some deep problem, you will see worksheets. Well, those kinds of experiences can send messages to children or students that they are dumb, that they are not smart, and so I'm challenging us to really problematize this notion of tracking, and how can we work with our partners and our districts and the teachers to really help them think about: maybe we need to change the type of instruction that is happening in these classrooms.

The final thing is that the goal of schooling is still cultural reproduction. How might a high school math teacher describe a good student? Just call it out. How would a high school student, or high school math teacher, describe a good student in her class? What is she going to say?

(audience response) Smart.

He does the homework, bright, quick, anything else?

(audience response) Pays attention.

Pays attention. Intuitive. That's the language that using. And we understand that this type of reproduction is still embedded with white, middle-class values, as several scholars have shown. Another scholar to read is Zevenburgen. Specifically, she wrote, "Cracking the Code of Mathematics Classrooms: School Success as a Function of Linguistic Social and Cultural Backgrounds." And it was in the multiple perspectives on math teaching and learning book. But her work is very, very powerful. She looks at actual exam questions, like ACT and those kinds of things, and really deconstructs the type of language and the type of capital that a student needs to bring to a math classroom to be successful. She really breaks it down, and it's something I encourage you to read.

Here are some of the tensions that I noticed in the work and the papers. Diversity, equity, and social justice appear to be synonymous and so one thing that you might want to think about is: are they synonymous? And if they are, state that emphatically and be able to explain how they are synonymous. If they are not, then think about maybe deconstructing some of that to really show what are the nuances, what do you actually mean by diversity? Are you talking about racial diversity? Are you talking about religious diversity? What kinds of diversity are you actually talking about? The second thing is the cultural scripts that we have in school, such as testing, procedural, lack of political will, these things that existed in schools for hundreds and hundreds of years. They serve as barriers to the education world. Identifying them and thinking about how you disrupt them or tear them down as you are working together with the district and all of the partnerships, how do you think about that?

The last one is that mathematics teacher educators themselves often have difficulty modeling or demonstrating deep equity issues, because most of them are white, middle-class. When you think about who are the faculty, they're generally not going to be someone in poverty or maybe they never really have experienced it. I want this reality check for us. I want us to think about this. White faculty never really have to think about racial oppression. Racial oppression, in a way that many of our U.S. students in our classrooms have experienced. And don't run away from that or be afraid of that, but really think about that. I mean, even me as a racialized black woman, I still bring a lot of privilege as a university professor, right? I have to think about my privilege and what that looks like, how that's shaping my students' experiences when I am teaching mathematics or math content courses. I don't know if the number has gotten higher or lower, but the last number I looked and checked was about 85% of public school teachers are white women. That's who I see in my methods classes. Who do you guys see in your methods classes? White students, right? So how do we help them understand not just this sort of ubiquitous term "equity" but in-depth understanding of this country's historical atrocities around education and understand how even today, that's impacting their future students that they're going to have in their classroom. I will tell you that it doesn't matter how wonderful the teachers here are and all the tricks that we have, if we don't believe in the student, if we don't build relationships with the student. It's hard when you have 150 students, but it can be done.

Who exactly are the transforming mathematics teacher education preparations for? Who are you doing this for? How might you nuance diversity, equity, and social justice if you state the clarity of your goals with the meaning of equity, which I put in parentheses because it's, again, sort of nebulous. We don't really know what we mean. And when I say "we," I'm talking about the field, period. How might you support math teacher educators? And I'm talking about the faculty like us, the faculty who teach these courses, around training for things like racial consciousness, understanding oppression, whiteness in mathematics and mathematics education. And this is a shameless ploy, but I have an edited book, "Interrogating Whiteness and Relinquishing Power." The subheading is "white faculty's commitment to racial consciousness in STEM classes." So I set out to find white faculty in STEM, science and math, that were trying to do this work, and to have them respond to what I think were really challenging and hard questions, and they produced beautiful narratives around how it [their racial consciousness] transformed their teaching. We are learning that faculty are using the book to conduct book studies, and that is exciting. If you've never read it or never heard of it, again, I encourage you to think about how you might use it.

Figure 3. Book cover.

How might we change the nature of mathematics teaching to be one of teaching as a transformative practice rather than the way we teach math, high school math and middle school math? I mean, it's not attractive if you're not learning how to be a teacher to really transform lives. You know, when I taught math, I tried to explain to my students by giving them experiences to show them the utility and the power of mathematics, to really be able to read their world, to change their world, to create models, to ask questions. That was my goal, because, you know, students say, "Why are we doing this? Why is this important?" You want students to understand that math is amazing. It's like the best thing since sliced bread. And I think we have to draw them in, but we have to draw them around what matters to them. Again, something to think about.

The last thing is: how might you promote an active-based policy agenda, because you have an ambitious mission statement. How do you do this with the current administration that really devalues science and intersectionality of students? How do you challenge that? How do you address that? Finally, I want to share some ideas for the equity group. Lesson studies are extremely powerful; I believe in lesson studies. But we might think about beginning with teacher indicator ourselves, so as to actively model for our teacher candidates in our program, trying to really understand what are the interlocking systems that are getting in the way of the advancement of what we are looking for? I mean, we say success but what do we mean? I'm a believer in the Common Core standards. I love the eight Standards for Mathematical Practices. But how do we help kids think about the power of mathematics beyond school, beyond coming to your class, so that they can begin to make connections, deep connections, to see really the power of what math can do? Collaborate with racially diverse thinkers.

If you want to diversify teacher candidates, then let's talk about the work of Toya Jones Frank and Jonee Wilson. Dr. Frank received an amazing NSF award to study black math teachers and to do oral histories of black math teachers that were teaching in the '60s and the '70s, as well as current teachers, and then to think about what might we be able to learn that specifically can help us think about recruitment. What do we need to think about when we're trying to recruit black teachers, for example? Black math teachers? It's an incredible project that I would encourage you to look up or call her, as she's doing some amazing work. Jonee Wilson, she's working on some equity observation protocols. I know she has a paper under review with JRME about some math practices for African-American students. And finally, stay "woke" and push back. Do we all know what I mean by stay woke and push back? That means stay conscious. Like, when you tell your children when they're small and they're walking to school or whatever, "make sure you know your surroundings, be conscious," well it's the same kind of thing. Be conscious and push back. If transforming is what we are going to do as an organization, then we have to be informed. Thank you very much.

RESEARCH ACTION CLUSTER REPORTS

Clinical Experiences

Marilyn Strutchens, Auburn University, strutme@auburn.edu

Ruthmae Sears, University of South Florida, ruthmaesears@usf.edu

Jeremy Zelkowski, University of Alabama, jzelkowski@ua.edu

Mark W. Ellis, CSU Fullerton, mellis@exchange.fullerton.edu

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 (CCSS) and teachers are especially inexperienced with embedding the standards for mathematical practice into their teaching of content standards on a daily basis.
2. Bidirectional relationship 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 Common Core State Standards for Mathematics (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 RAC (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. We use Dropbox and Trellis as a way of sharing files and materials. We 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 (National Council of Teachers of Mathematics [NCTM], 2014), PD for mentors related to the CCSS and mentoring mathematics teacher candidates, and outcome measures. There are also specific goals to be attained within each of the sub-RACs. 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 2016 MTE-Partnership conference was the submission of a proposal to the Engaged Student Learning, Design or Development and Implementation (level 2) of IUSE of the National Science Foundation. The project will be led by principal investigators from Auburn University, University of South Florida, and the Association of Public and Land-grant Universities (APLU). *Collaborative Research*: *Attaining Excellence in Secondary Mathematics Clinical Experiences with a Lens on Equity* will implement 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).

During the 2017 MTE-Partnership conference, we began to prepare for the implementation of the grant, since we had received questions related to the proposal from the program officer, which in the past has been a good sign to principal investigators that their projects were going to be funded. We are hoping that this grant will help us to extend the work that we have already begun.

In addition to making preparation for the implementation of the grant the sub-RACs work 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 2016 MTE-Partnership conference.

Methods Sub-RAC

The methods sub-RAC has developed, field tested, and posted a three-component module (available in the Clinical RAC Trellis library) that focuses on understanding and identifying the Standards for Mathematical Practice (SMPs). The activities include a component near the end of the module for teacher candidates to work briefly with their cooperating/mentor teacher to analyze a video clip through the lens of the SMPs. The online surveys of each different part of the module are being converted to Google forms for easy download and use and will be ready by the early part of August 2017.

The second module being developed focuses on short-term lesson planning and will include a component in which teacher candidates work with their cooperating teacher near the completion of the lesson plan to receive feedback on lesson planning using a rubric derived from the MCOP^2. This module will be field tested in Fall 2017 at two universities and again in Spring 2018. The goal is to finalize the module at next year's MTE-Partnership conference and have it ready for sharing for Fall 2018.

A third module focusing on developing skill with providing formative feedback to students regarding their mathematical reasoning was started by new RAC members at the June 2017 MTE-Partnership conference. This module will focus on helping teacher candidates learn to provide objective/goal-driven feedback to students' mathematical work. It is anticipated the module will conclude with a task that will include the cooperating teachers working with the teacher candidates to provide formative feedback to students in the classroom in which the teacher candidates are placed.

Co-Planning and Co-Teaching Sub-RAC

During the MTE-Partnership annual meeting, which was held June 25-27, 2017, the Co-Planning and Co-Teaching (CPCT) sub-RAC actively engaged in outlining the PDSA cycles for the next academic year. Particularly, the group worked on three major agenda items, namely: determining attributes of a website that can be used to disseminate information to mathematics teachers about CPCT; core tenets that ought to be addressed during the working group sessions at the 2017 PME-NA meeting that will be held October 5-8, 2017; and refining the instruments that would be incorporated into the NSF-IUSE grant efforts, if it is funded.

For the website, it was recommended that model videos of CPCT during enacted lessons and resources that teachers can use immediately within their settings be easily accessible and downloadable. For the PME-NA meeting, the group considered how to support the need of institutions who are seeking to adopt CPCT for the first time, while supporting institutions who have implemented it more readily. Moreover, the sub-RAC also considered means to consolidate survey items further. The sub-RAC agreed to meet at the beginning of the academic year to continue their discussion about the three agenda items, and will identify a suitable schedule for data collection.

Paired Placement Sub-RAC

The paired placement sub-RAC consolidated folders and began work to make the materials more accessible to others interested in piloting the model. Members of the sub-RAC also worked on refining PDSA cycle questions for fall 2017 implementation of the model. Members of the paired placement sub-RAC are currently working on an article related to the implementation of the paired placement approach. They are also making plans for presentations and other ways of disseminating the work. Members were also working with the other sub-RACs to ensure that the Mathematics Teaching Practices Survey is available online and is in a form in which the data can be easily read.

Summary

Overall the clinical experiences RAC is making great progress toward its aim. Members work well together and are constantly learning from each other. The work is exciting, rewarding, and transformative. Below are ways that MTE-Partnership members can get involved in the sub-RACs.

Early Field Experiences within Methods Sub-RAC

1. Implementing the SMPS module and contributing to data collection; and
2. Collaborating on the development of additional modules and measures of module effects on teacher candidates and mentor teachers

Co-Plan/ Co-Teach Sub-RAC

1. Developing, utilizing, and sharing instruments used to measure the influence of the co-teaching model;
2. Implementing the model and examining teacher candidates' experiences throughout their field-based preparation (i.e., practicum and internship); and
3. Studying the influence of professional development on the success of the co-teaching model.

Paired Placement Sub-RAC

1. Developing, utilizing, and sharing instruments used to measure the influence of the paired placement model;
2. (2) Implementing the model and examining teacher candidates' experiences throughout their field-based preparation (i.e., practicum and internship); and

3. Refining and studying the influence of professional development and orientation sessions on the success of the paired placement model.

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. & Cofer, L.D. (2014). Mathematics classroom observation protocol for practices results in undergraduate mathematics classrooms. In (Eds.) T. Fukawa-Connelly, G. Karakok, K. Keene, and M. Zandieh, *Proceedings of the 17th Annual Conference on Research in Undergraduate Mathematics Education*, 2014, Denver, Colorado, 93-103.

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)

Wendy Smith, University of Nebraska-Lincoln, wsmith5@unl.edu
David Webb, University of Colorado Boulder, dcwebb@colorado.edu
Co-Leaders

Problem Addressed

Student success in undergraduate mathematics has significant implications for whether they choose to continue into STEM majors and related careers in the future. Even for those students who do not choose to major in mathematics, science, or engineering, success in entry-level undergraduate mathematics courses such as calculus can make or break their decision to persist in postsecondary education.

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 (DFW) ranged from an average of 25 percent at Ph.D.-granting universities to an average of 37 percent at regional comprehensive universities. We are committed to improving students' achievement in and dispositions toward mathematics using models for Active Learning Mathematics (ALM).

With respect to the MTE-Partnership's Guiding Principles, the ALM RAC involves *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 also have the potential to encourage more students to consider becoming secondary mathematics teachers (or at least reduce discouragement among potential future teachers).

General Approach

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

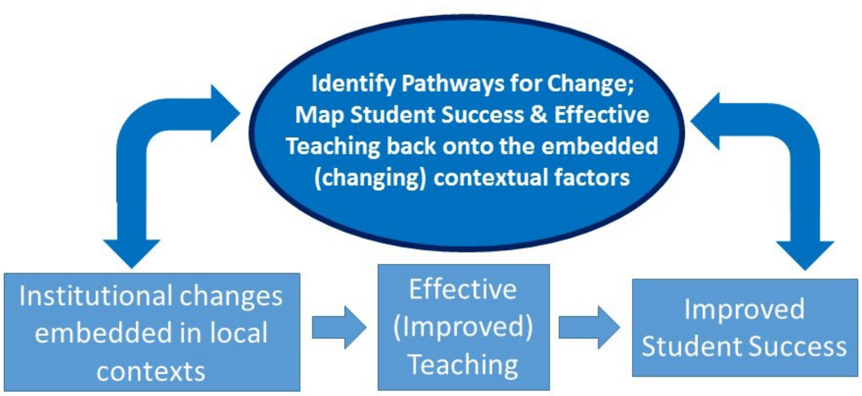


Figure 1. ALM RAC theory of change.

The overarching goal is to improve student success with undergraduate mathematics, starting with the Pre-calculus through Calculus 2 sequence (P2C2). This 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.

Table 1

Who We Are

Auburn University Gary Martin, Ulrich Albrecht	**University of Colorado Boulder** David Webb, Robert Tubbs, David Grant Faan Tone Liu, Eric Stade, Nancy Kress
California State University Fullerton David Pagni, Roberto Soto	**University of Hawaii Manoa** Monique Chyba, Mijana Jovovic
California State University Chico Christine Herrera	**University of Nebraska-Lincoln** Wendy Smith, Allan Donsig, Nathan Wakefield
Florida International University Maria Campitelli	**University of Nebraska Omaha** Janice Rech, Michael Matthews
Fresno State University Lance Burger	**University of South Carolina** Sean Yee
Kennesaw State University Kadian Callahan, Belinda Edwards	**West Virginia University** Vicki Seeley, Nicole Engelke, Matthew Campbell
San Diego State University Chris Rasmussen, Janet Bowers, Michael O'Sullivan, Matt Voigt, Naneh Apkarian	**Western Michigan University** Tabitha Mingus, Melinda Koelling
Tuskegee University Lauretta Garrett, Ana Tameru	

Current Progress

Over the past four 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, pre-requisite courses for pre-calculus, 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.

Opportunities for Engagement

A collaborative NSF-funded research grant – Student Engagement in Mathematics through an Institutional Network for Active Learning (SEMINAL) – now supports research to better understand how to enact and support institutional change in P2C2 courses. SEMINAL is actively soliciting additional partners ready for institutional transformation to join in this research project (see http://tinyurl.com/SEMINALIntro).

The Active Learning 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).

Work of the 2017 Conference

During our RAC work time at the June 2017 MTE-Partnership conference, we first spent time learning what progress each campus has made. We also spent time revising our driver diagram (see below). We discussed data extensively, including:

- The importance of attending to the variances in the data
- Considering a broad range of data from DFW rates to student attitudes to classroom observations
- The need to examine subgroups of students, not just overall averages (e.g., how do we know our students' needs and develop appropriate supports for them? Are our efforts working equally well with all subgroups?)
- Ways to access university data (registration, grades), to track student trajectories, majors and grades
- Options for surveys; while the ALM RAC has been encouraging use of the Collegiate Active Learning in Calculus Survey (CALCS), SEMINAL has developed other options. CALCS primarily measures beliefs, along with intent to take more mathematics courses and some other student characteristics. SEMINAL has adapted the Postsecondary Instructional Practices Survey (PIPS) for instructors, and developed the SPIPS—a version of the PIPS for students that can be correlated with PIPS data. Further, SEMINAL has a Climate and Culture Survey for mathematics departments, to gauge the instructional climate and professional advice networks related to mathematics teaching. ALM RAC members can choose any/all of these surveys.
- Survey administration: how surveys are administered matters greatly for response rates. For faculty, ideally the department chair sends out surveys; at a minimum, the chair should send out a notice about the surveys and to stress their importance to the department. If the survey is administered via Qualtrics, then the system can send personalized reminders (only to those who have not completed the survey). For students, the CALCS survey is pre/post, so the survey requires a student identifier to link the two. SPIPS is just given once near the end of the semester. If one wants survey results tied to university data like grades, then student IDs need to be collected in the surveys. Students typically need an incentive to complete the survey(s), such as bonus points, or having the survey worth a

homework or quiz grade. Setting aside time during class to complete the survey typically results in much higher response rates than just emailing students a link to the survey. Given the ALM RAC members' experiences, having the student survey completed during class, and worth a quiz or homework grade yield the highest response rates.

- The WebWork homework system (open-source from the MAA) allows for customization of problems and the "hint" button. UNL problems for college algebra, precalculus, calculus 1 and calculus 2 are all available for sharing. The system can generate useful data for examining student learning.
- It can be very informative and useful to interview students. One can ask a class to nominate one person per group to attend a focus group interview. Students often have good insights into how various instructional approaches and classroom norms affect their interest, engagement and performance in the course.
- Observing courses helps to assess how successfully ALM strategies are being implemented. Also, having an observation protocol ($MCOP^2$) can help structure a reflective conversation of the observer and instructor after an observation. There is a need for more $MCOP^2$ training. At UNL, they have adapted the COPUS for a more math and ALM focus, and have been using that to structure observations.
- Sharing and publishing data requires an approved IRB protocol. UNL has an "umbrella" IRB to cover ALM RAC data collection and analyses. If your IRB will defer to UNL's, then you can be added to this protocol to cover your data collection and sharing de-identified data with the RAC.

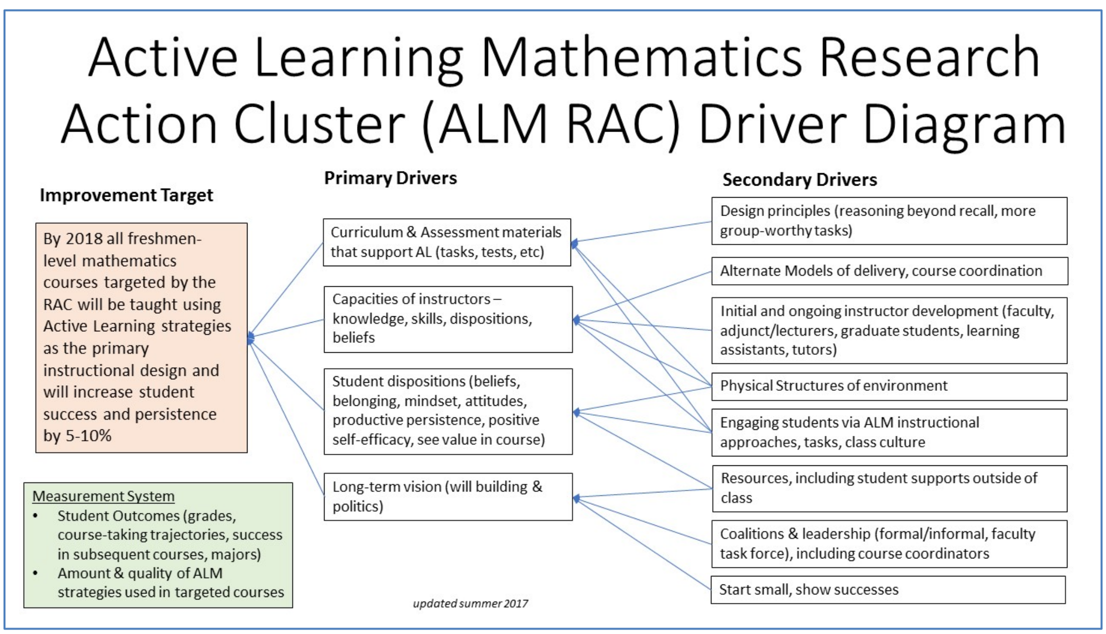


Figure 2. ALM RAC driver diagram, revised Summer 2017.

The ALM RAC work time was also used to discuss course coordination. Two key questions were: where is coordination used and what is common across partner campuses? Related to these two large questions, we discussed whether coordination is a starting point or level for change, or if coordination already exists and so it can be a tool for change. In the absence of course coordination, student success across sections is typically highly variable; this data can then be a motivating factor for change. A key question in course coordination is: Who is responsible? Who decides a course will be coordinated, and who enforces instructor compliance with coordination? While some course coordination is very loose (e.g., just a common syllabus/homework), other coordinated aspects include: grading scale, grading scheme (weight of components to grades), common exams, common grading/rubrics for common exams, textbook, homework, quizzes, lessons/activities, calculator/technology use and policy. Further, "vertical coordination" can help students to experience coherence throughout the common sequence precalculus → calculus 1 → calculus 2 → calculus 3.

The ALM RAC planning discussion also touched on how to provide extra support for students who are not succeeding in courses. Three main strategies include the supplemental instruction model (CSU Fullerton), an extra recitation (Western Michigan), and individual interventions (UNL). Often, by the second or third week of class, we can identify students most at risk for failing. However, once students have been identified how do we then successfully (re)engage those students? Issues that lead to student failure often extend beyond "the math" to motivation and "life skills" (how to be a college student, time management, etc.)

For the 2017/18 school year, the ALM RAC work will include:

- Monthly meetings of the RAC members, to include some pre-determined 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.)
- Identifying ways to leverage intersections with SEMINAL project resources and emergent findings
- Recognizing that the SEMINAL Phase II award process may increase the number of RAC partners, articulate ways to manage coordination and communication among existing and new partners going forward
- Implementing common data collection and data analyses.

References

Bressoud, D., Carlson, M. P., Mesa, V., & Rasmussen, C. (2013). The calculus student: Insights from the Mathematical Association of America national study. *International Journal of Mathematical Education in Science & Technology, 44*(5), 685-698.

MODULE(S^2) RAC Report: Blending Content and Mathematical Knowledge for Teaching in Mathematics Courses

Alyson Lischka, Middle Tennessee State University, Alyson.Lischka@mtsu.edu
Emina Alibegovic, Rowland Hall-St. Mark's School, eminaalibegovic@rowlandhall.org

Overview and Problem Statement

The Mathematics of Doing, Understanding, Learning, and Educating for Secondary Schools [MODULE(S^2)] Research Action Cluster (RAC) is focused on the development of prospective secondary mathematics teachers' (PSMTs') knowledge of mathematics content needed to support student learning. 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). 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(S^2) 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.

We adopted the Mathematical Knowledge for Teaching (MKT; Hill, Ball, & Schilling, 2008) framework for our work. In this framework, subject matter knowledge for teaching mathematics not only includes the mathematics one teaches (Common Content Knowledge [CCK]), but also knowing mathematics in a specialized way to meet the demands of teaching (Specialized Content Knowledge [SCK]) and the broader landscape of mathematics in which the mathematics one teaches is situated (Horizon Content Knowledge [HCK]). Pedagogical Content Knowledge (PCK) is also included in this framework, because it is specific to teaching mathematics. PCK includes three components in the MKT model: knowledge of how students conceive of particular mathematics topics (Knowledge of Content and Students [KCS]), pedagogical principles for teaching specific content topics (Knowledge of Content and Teaching [KCT]), and knowledge of the curriculum resources available for the teaching of specific content and how to sequence their use to enhance student learning (Knowledge of Content and Curriculum [KCC]). Hill, Rowan and Ball (2005) showed that teachers' MKT is positively correlated with student achievement, so growth of PSMTs' MKT could have powerful effects on students' STEM achievement.

Smith, W. M., Lawler, B. R., Bowers, J., & Augustyn, L. (Eds.). (2017). *Proceedings of the sixth annual Mathematics Teacher Education Partnership conference*. Washington, DC: Association of Public and Land-grant Universities.

Current State of the Work

In the 2015-2017 academic years, the MODULE(S^2) RAC continued work on multiple fronts: writing and revising modules in Geometry and Statistics, piloting existing modules in a variety of locations, planning for modules in Algebra and Modeling, presenting results of pilot studies, and submitting a successful proposal for an NSF-IUSE grant to fund the work of the MODULE(S^2) RAC.

Both the Geometry and Statistics sub-groups engaged instructors to pilot materials this year. The Statistics group, led by Stephanie Casey and Andrew Ross, established piloting agreements during 2016-2017 with instructors at Auburn University, Boise State University, University of Arizona, Salisbury University, and California State University Chico. The research team designed the mini-instructional module "Statistical Knowledge for Teaching Bivariate Categorical Data Analysis." Instructor and student versions of the module were created and distributed to all piloters. Results of an initial pilot of these materials were presented at the Psychology of Mathematics Education – North American Group meeting in October 2015 (Casey, Ross, Groth, & Zejnullahi, 2015). These results indicated that learners engaging with the materials developed a broader awareness of a variety of misconceptions involving categorical association and improved their own understanding of the topic. Further development of this module and others is in progress.

The Geometry group, led by Emina Alibegovic and Alyson Lischka, collaborated with piloters in spring 2017 at California State University Monterey Bay, Auburn University, University of North Dakota, and Grand Valley State University. In February 2017, at the Association of Mathematics Teacher Educators annual conference, Lischka and Jeremy Strayer (along with two doctoral students from Middle Tennessee State University) presented results from a pilot study conducted on the Geometry Modules in Spring 2016 (Lischka, Strayer, Alibegovic, Watson, & Quinn, 2017). The group shared elements of the modules and pre- and post-assessments of student work that resulted from the course. Results indicated that students engaging with these modules increased their mathematical knowledge for teaching geometry according to the Silverman and Thompson (2008) framework. The session was well attended and the audience thoughtfully engaged with the discussions, helping MODULE(S^2) spread the word of our work. Revisions of the Geometry Modules continue based on feedback from piloters and the results of the pilot study.

In January 2017, the MODULE(S^2) RAC submitted an NSF-IUSE proposal for a five-year project to develop, pilot, and revise modules for use in College Geometry, Statistics, Mathematical Modeling, and Abstract Algebra. The collaborative proposal, *Collaborative Research: Mathematics of Doing, Understanding, Learning and Educating for Secondary Schools* (NSF Awards #1726707, 1726098, 1726252, 1726723, 1726744, and 1726804), was awarded full funding beginning September 1, 2017. The goals of the project are:

1. Refine and continue to develop instructional materials in two areas (Geometry, Statistics) that have been shown in pilot studies to develop PSMTs' 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 MODULE(S^2) grant team is led by Strayer (Middle Tennessee State University) and Howard Gobstein (Association of Public and Land-Grant Universities). Collaborators include: Alibegovic (Rowland Hall School), Cynthia Anhalt (University of Arizona), Jason Aubrey (University of Arizona), Casey (Eastern Michigan University), Brynja Kohler (Utah State University), Yvonne Lai (University of Nebraska – Lincoln), Lischka (Middle Tennessee State University), and Ross (Eastern Michigan University).

The MODULE(S^2) RAC used work time at the Mathematics Teacher Education Partnership June meeting to organize the logistics of the work of the grant and set specific goals and timelines for making significant progress on the writing of the modules within the first year of the grant.

Moving Forward

In the 2016-2017 academic year, the writing team will move forward with the drafting of all student materials for Algebra, Statistics, and Modeling. The Geometry team will focus on revision of the student materials and drafting of the instructor materials. Inter-writing-team reviews of all materials will be conducted. The team will also seek up to two funded piloters to implement the materials along with all data collection as a pilot study during Fall 2017. Additional funded piloters will be invited to participate for the 2018-2019 academic year. In June 2018, the team will provide professional development for those instructors piloting materials in the 2018-2019 academic year. During development and piloting, materials will be available to piloters through Trellis.

For More Information

Contact Alyson Lischka, Middle Tennessee State University, Alyson.Lischka@mtsu.edu or Emina Alibegovic, Rowland Hall-St. Mark's School, eminaalibegovic@rowlandhall.org.

References

Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education.* Chapel Hill, NC: Horizon Research, Inc.

Casey, S., Ross, A., Groth, R., & Zejnullahi, R. (2015). Developing teachers' knowledge of content and students for teaching categorical association. In T. Bartell, K. Bieda, R. Putnam, K. Bradfield, & H. Dominguez (Eds.) *Proceedings of the 37th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education,* pp. 872–875. East Lansing, MI. Retrieved from https://pmena2015.org/info/proceedings

Conference Board of the Mathematical Sciences. (2012). *The Mathematical Education of Teachers II*. Providence, RI, and Washington, DC: American Mathematical Society and Mathematical Association of America. Retrieved from http://www.cbmsweb.org/MET2/MET2Draft.pdf

Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education*, *39,* 372-400.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal*, *42*, 371-406.

Lischka, A. E., Strayer, J., Alibegovic, E., Watson, L, & Quinn, C. (2017, February). *Building mathematical knowledge for teaching geometry in a secondary content course: geometry and beyond.* Presentation at the Annual Meeting of the Association of Mathematics Teacher Educators, Orlando, FL.

Silverman, J., & Thompson, P. W. (2008). Toward a framework for the development of mathematical knowledge for teaching. *Journal of Mathematics Teacher Education, 11*(6), 499-511.

Program Recruitment and Retention (PR^2) Conference Working Group Report

Julie McNamara, California State University (CSU) East Bay, julie.mcnamara@csueastbay.edu
Dana Franz, Mississippi State University, dana.pomykal.franz@colled.msstate.edu
Maria Fernandez, Florida International University, mfernan@fiu.edu

Overview

The PR^2 Research Action Cluster (formerly known as the MATH RAC) convened on June 25 for the first of three working sessions during the MTE-Partnership annual conference. The RAC continued the work started at a convening held in Dallas over the weekend of January 21 and 22 with the goal of revising the driver diagram to reflect our dual goals of program recruitment and program retention, and to put the need for attending to issues of diversity, equity, and social justice at the forefront. The RAC agreed that its initial goal of producing a document to guide marketing campaigns had been reached with the completion of the *Secondary Mathematics Teacher Recruitment Campaign Implementation Guide*. Present at the January meeting were Dana Franz, Maria Fernandez, Carol Fry Bohlin (via Skype), Jim McKown, Gary Martin (facilitator), Ed Dickey, Cheryl Roddick, Jan Smith, and Laurie Cavey. During the January gathering we reaffirmed our agreement that the general aim of the RAC (i.e., to increase the supply of well-prepared, diverse candidates completing our secondary mathematics teacher preparation programs) had not changed but we needed to redefine how to address the challenges impeding progress toward our goal. This work led to the revised Driver Diagram shown in Figure 1.

In addition, we began identifying "change ideas" and sent out a draft to the group. While the leadership team received some feedback from the larger RAC during the spring, we knew that we would need to address the change ideas more thoroughly when we were together at the June Conference. The solicitation for the PR^2 RAC is shown in Appendix A.

An ongoing challenge for secondary schools (grades 6-12) in the United States is the number of students being taught by under-qualified mathematics teachers (Hill & Gruber, 2011; Ingersoll, 2005). Increasing school enrollment coupled with both a significant increase in the number of teachers leaving the classroom as well as increasing opportunities for women to find better paying work outside of the profession of teaching raise concerns about a potential deficit in the teacher workforce (Ingersoll & Perda, 2010). This results in out-of-field teaching where teachers may be credentialed to teach in another discipline but are teaching one or two mathematics courses. The problem of under-qualified teachers is even more critical in high-poverty and rural schools where it can be more challenging to fill positions with teachers (Hill, 2007). Further, teaching assignment practices within schools often place the least prepared teachers with the students who need a highly qualified teacher the most (Kalogrides, Loeb, & Beteille, 2011).

Within the last decade, mathematics teacher preparation programs have focused on developing marketing campaigns to broaden the attention of teaching as a career (e.g., the Teach Science and Mathematics campaign at the University of South Carolina). Motivated, in part, by the national "100K in 10" effort to train 100,000 highly qualified STEM teachers by 2021, these marketing campaigns strive to change potential teachers' (and others') perceptions about teaching. The development of a marketing campaign includes careful attention to the target audience, branding, social media, public relations, and the web identity of the program. However, we need to understand how these campaigns are impacting the recruitment and retention of teachers.

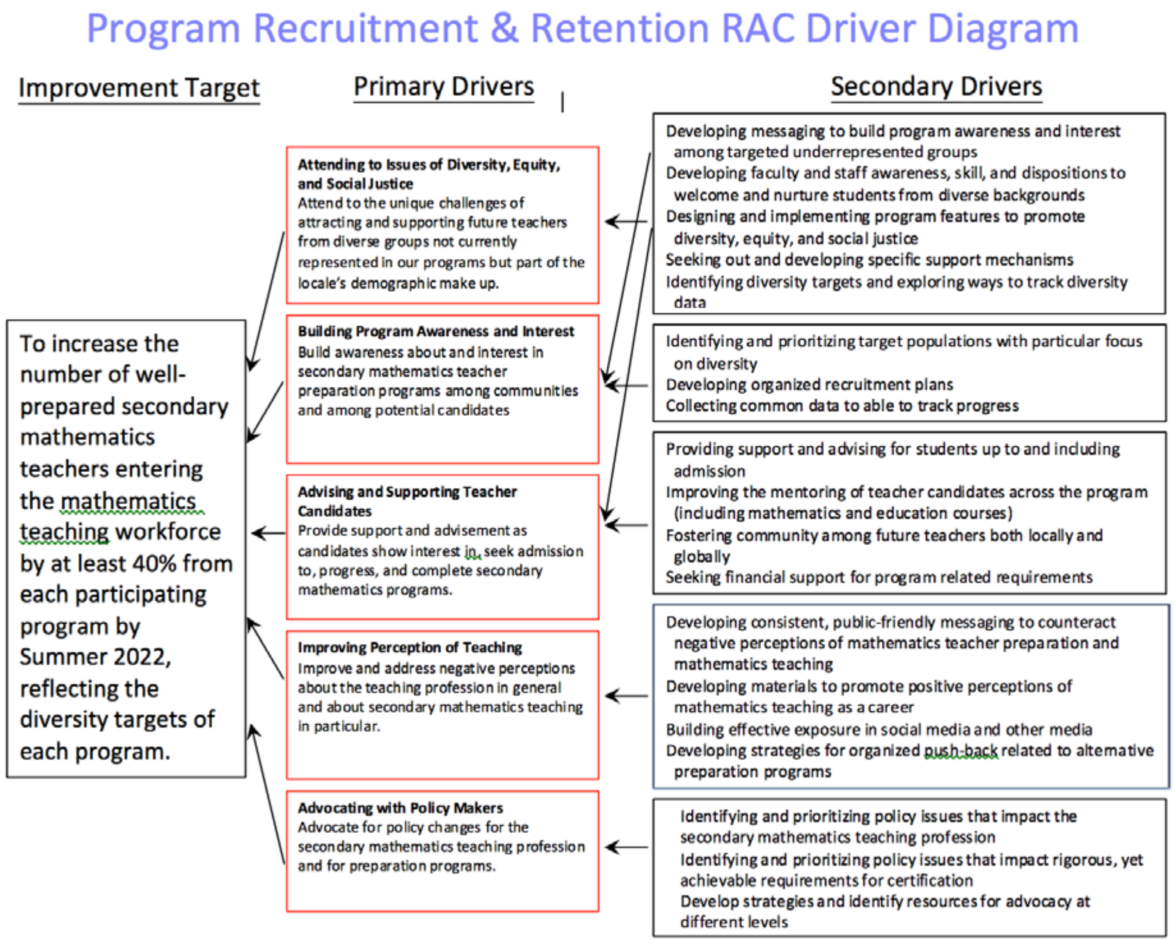


Figure 1. PR^2 revised driver diagram.

Table 1

Present at the MTE-Partnership 2017 Conference

Dana Franz, Mississippi State University	Shawnda Smith, University of Texas at Austin
Maria Fernandez, Florida International University	Ed Dickey, University of South Carolina
Charmaine Mangram, University of Hawaii	Cheryl Odorica, California State University Chico
Margaret Schroder, University of Kentucky	Kathy Hann, California State University East Bay
Seth Jones, Middle Tennessee State University	Julie McNamara, California State University East Bay
Sally Millsap, Middle Tennessee State University	

What We Accomplished at the Conference

During our first session at the June conference, Dana Franz presented the new Driver Diagram and Preamble to the group. As we anticipated, a great deal of time was spent clarifying drivers and terminology. To facilitate this work, the RAC members split into two working groups. One group worked on defining terminology, in particular, the terms equity, diversity, and social justice. This resulted in draft definitions that will be sent to the entire RAC for feedback and revisions. The second working group addressed the redundancy of secondary drivers. This is work that the RAC will continue to address moving forward.

During our second work session on June 25 the RAC began by reviewing the change ideas that came out of the meeting in January. Our attempt to prioritize the change ideas led the RAC to realize we were not consistent. One "big idea" that was voiced by Ed Dickey was the realization that, with the exception of Cheryl Odorica at CSU Chico, the work of the RAC is not included in any of our actual positions; it is above and beyond our primary responsibilities.

What We Are Working on Going Forward

Based on our attempts to revise and refine our secondary drivers and change ideas the RAC members agreed to formalize the recruitment plan at their institutions using the language of our Driver Diagram. (End of August due date.) The RAC members also agreed on the importance of creating common structures for reporting on and sharing data regarding recruitment and retention efforts (see Appendix B). As a result, the RAC decided to undertake a PDSA cycle for reporting on recruitment and retention efforts using a common format. The RAC members who were present at the conference will pilot the common format shown in Appendix A by our next conference call on September 20. Revisions will be made as needed and the data collection will be extended to the rest of the institutions in the MTE-Partnership.

Appendix A

Solicitation for Participation in the

PR^2 Program **R**ecruitment and **R**etention **RAC**

June 2017

Problem Addressed

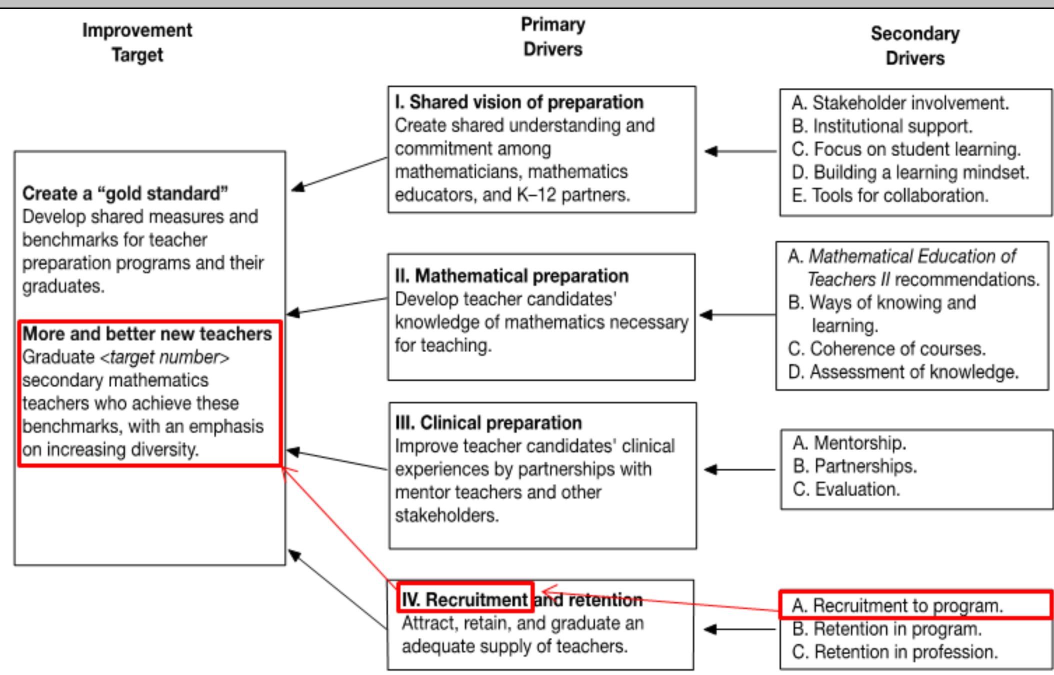
Guiding Principle 8. Student Recruitment, Selection, and Support: The Teacher Preparation program actively recruits high-quality and diverse teacher candidates into the program and supports their success in completing the program.

Problem:

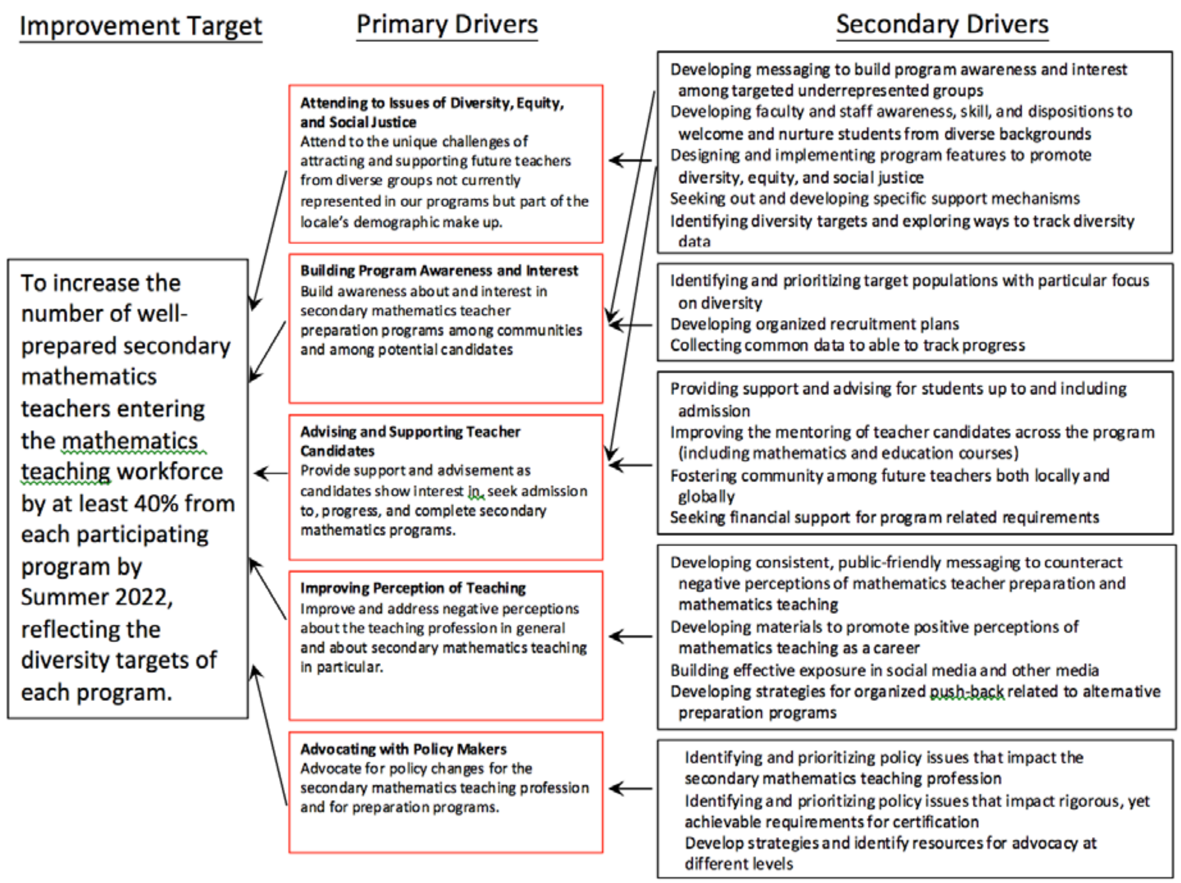
- Secondary Mathematics Teacher Programs* (SMTPs) are not enrolling or graduating secondary mathematics teachers to satisfy the needs of U.S. middle and high schools
- Current teachers and teacher candidates do not reflect the diversity of the K-12 US student population
- Salary, stereo-types, job-satisfaction, career prestige, and the challenges of learning mathematics contribute to low enrollments in mathematics teacher preparation programs

* An SMTP is a program that includes a nationally accredited course of study housed at an institution of higher education that leads to licensure for teaching mathematics in grades 6-12.

General Approach



Smith, W. M., Lawler, B. R., Bowers, J., & Augustyn, L. (Eds.). (2017). *Proceedings of the sixth annual Mathematics Teacher Education Partnership conference*. Washington, DC: Association of Public and Land-grant Universities.



- Implementing models for developing and launching purposeful and sustained marketing campaigns that rebrand teaching to appeal to diverse populations
- Identify critical experiences in mathematics and clinical work that impact recruitment and retention
- Include adaptations for programs focusing on undergraduates, UTeach, alternative pathways, career changers, and other models.

Who We Are	
Cynthia Anhalt, University of Arizona, & **Maria Fernandez**, Florida International University	**Jennifer Whitfield,** Texas A&M University
Diane Barrett, Jim McKown, Linda Venenciano, and **Charmaine Mangram**, University of Hawaii	**Nadine Bezuk, Randy Philipp & Rafaela Santa Cruz**, San Diego State
(Ryan) Seth Jones and Sally Millsap, Middle Tennessee State	**Carol Fry Bohlin**, Fresno State University
Laurie Cavey, Joe Champion & Jan Smith, Boise State	**Kathy Hann, Julie McNamara & Julia Olkin**, CSU-East Bay & **Cheryl Roddick**, San Jose State
Ed Dickey, University of South Carolina	**Cheryl Ordorica,** CSU-Chico
Dana Franz, Mississippi State University	**Sofia Vicuna**, CSU-Monterey Bay
Margaret Mohr-Schroeder, U of Kentucky	**Gregory Chamblee,** Georgia Southern U.
Amy Nebesniak, University of Nebraska-Kearney	

Current Progress

Each partner is implementing ***Plan Do Study Act*** cycles tied to recruitment and using measures of program inquires and enrollments to monitor impact. Boise State, Middle Tennessee State, and FIU are addressing UTeach replication recruitment efforts. Arizona, Kentucky, Mississippi State, Texas A&M, and UofSC as well as the California State System campuses are implementing various strategies and recruitment tactics tied to their own programs. Efforts include website development, class meetings, posters, social media efforts and videos. Sample partner websites are at

- University of Arizona: **SMEP**: http://math.arizona.edu/~smep/
- Boise State University, **IDoTeach**: http://idoteach.boisestate.edu/
- California State University, **EduCorps:** http://teachingcommons.cdl.edu/csu_educorps
- Florida International University, **FIUTeach**: http://fiuteach.fiu.edu/
- University of Kentucky, **STEM Dept**: https://education.uky.edu/stem/
- Middle Tennessee State University, **MTeach**: http://www.mtsu.edu/mteach/
- Mississippi State: **CISE**: http://www.cise.msstate.edu/
- Texas A&M University, **AggieTeach**: http://aggieteach.tamu.edu/index.shtml
- University of South Carolina**,** **TeachScienceandMath**: http://teachscienceandmath.org

The RAC has created and disseminates a nine-module **Secondary Mathematics Teacher Recruitment Campaign Implementation Guide** available within Trellis and at ***http://bit.ly/****MATHImplGuide* .

- Module 1 Teacher Recruitment Campaign Overview
- Module 2 Campaign Planning
- Module 3 Campaign Research
- Module 4 Branding
- Module 5 Social Media
- Module 6 Public Relations
- Module 7 Paid Broadcast Media
- Module 8 Web Site Identity
- Module 9 Lessons Learned/Evaluation

RAC members share **recruitment tools** (flyers, posters, videos, websites, etc) at *http://padlet.com/ed_dickey/vhle4gisbq82*

The RAC continues to be aware of the work of the STRIDES RAC and aims to complement, but not duplicate, their efforts.

Opportunities for Engagement

- As a full partner, commit to implementing marketing tactics and share strategies, results, and data with RAC members. As participating partners, join in periodic conference calls to learn about activities and share information as appropriate.
- Share successful campaigns to further refine the Implementation Guide.
- Explore and implement strategies to diversify pool of teacher candidates and more effectively impact issues of equity and social justice in school settings.
- Explore the possibility of creating and working on sub-RACs.
- Participate in the building of a Recruitment Resources Collection with the new MTE-Partnership online communication and collaborative work platform with the AAAS Trellis site: http://www.trelliscience.com

Appendix B

Develop common format for reporting
After much debate, it was determined that we need to first collect information about our programs in some type of common format. Suggested at the conference as our initial data collection was the following format:

a. University Context
    i. Setting
    ii. Demographics
    iii. Type of institution
b. Program context
    i. Setting
    ii. Demographics
    iii. Type of program (Undergrad, Post-Bac, Grad, Combo)
c. Recruitment targets
    i. High schoolers
    ii. Community college students
    iii. Career changers
    iv. Current undergrads
    v. Current grad students
    vi. Campus organizations/clubs
    vii. Students at minority serving institutions (HBCUs, HSIs,…)
d. Recruitment strategies

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

Megan Taylor, Trellis Education, megan@trelliseducation.org
James Martinez, California State University Channel Islands, james.martinez@csuci.edu
Lisa Amick, University of Kentucky, lisa.amick@uky.edu

Overview of the STRIDES RAC Work to Date

Half of all teachers leave the profession within the first five years. 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 needs immediate attention. This crisis leads to many underprepared mathematics teachers and has 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 and 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.

Smith, W. M., Lawler, B. R., Bowers, J., & Augustyn, L. (Eds.). (2017). *Proceedings of the sixth annual Mathematics Teacher Education Partnership conference*. Washington, DC: Association of Public and Land-grant Universities.

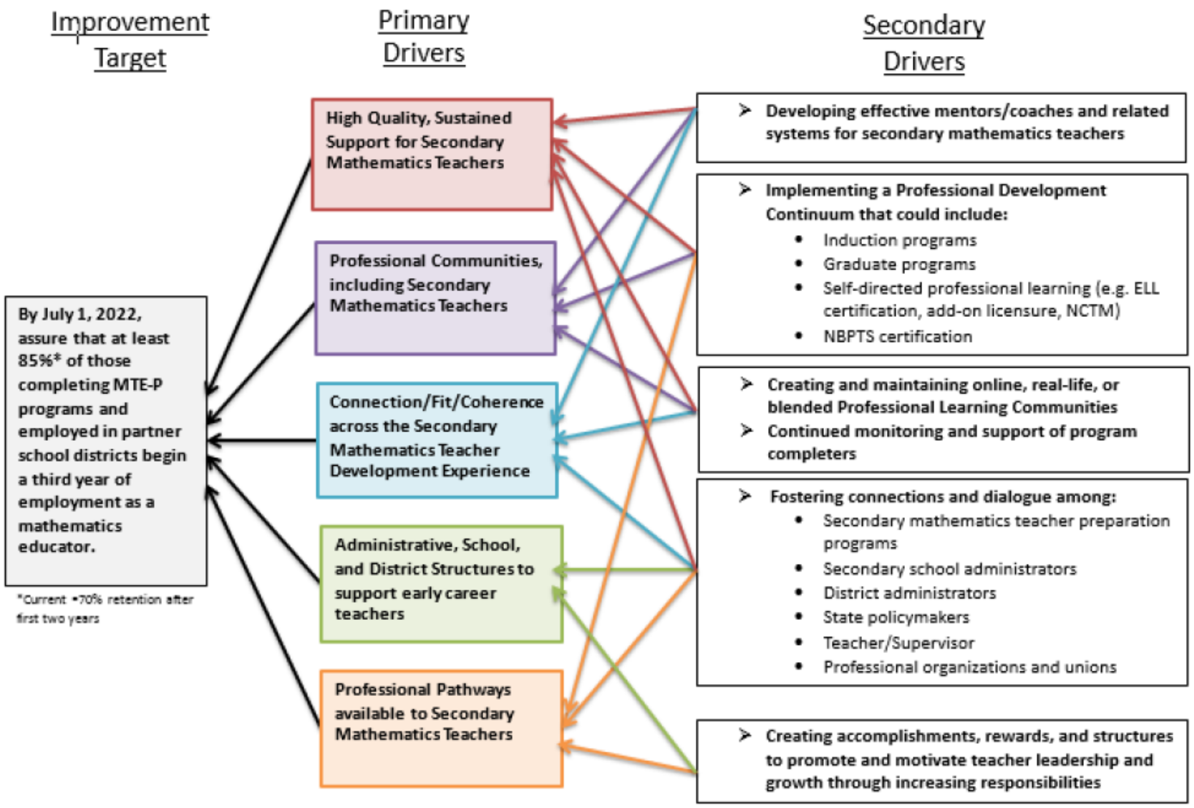


Figure 1. STRIDES driver diagram.

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. Data from this November 2016 survey was gathered from participants from a wide geographic area and included responses from 141 early career teachers across the USA (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 regional conferences, most recently at the 2017 MTE-Partnership Annual Conference in New Orleans.

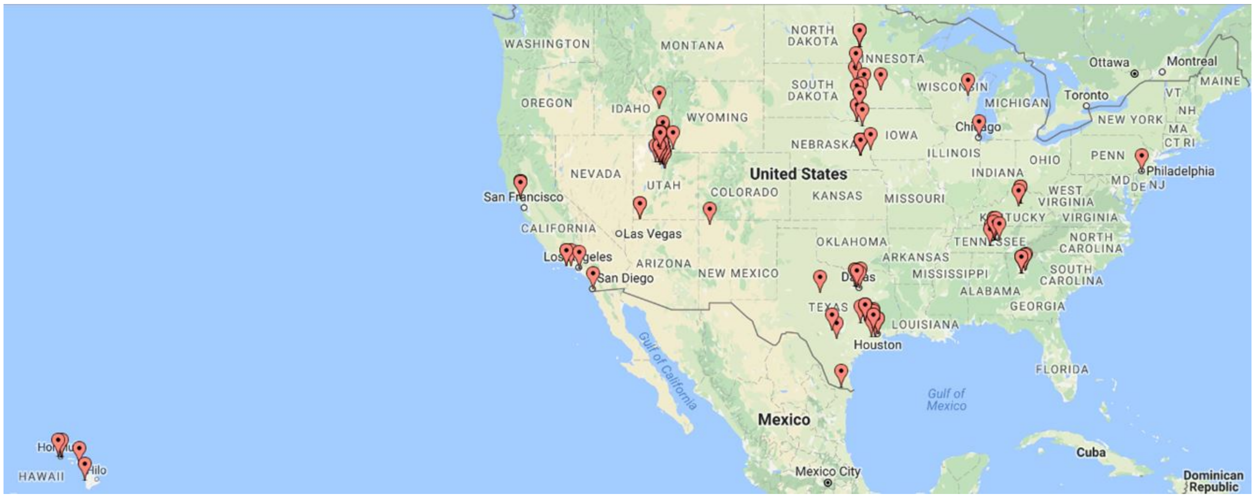


Figure 2. Geographic participation in the STRIDES survey.

Work of the STRIDES RAC at the 2017 Annual Conference

At the 2017 MTE-Partnership Annual Conference in New Orleans, 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), many of which were new to the RAC, having been "recruited" during open session time in the first morning (second day) of the annual meeting. Members included (with sub-RAC in parentheses): Christine Smith (Admin), James Martinez (Admin), Lisa Amick (Mentoring), Josh Males (Admin), Lorraine Males (Admin), Fred Uy (Mentoring), Joleigh Honey (Mentoring), Diana Suddreth (Mentoring), Linda Hirashi (Mentoring), Judy Kysh (Mentoring), Robin Hill (Mentoring), Craig Schroeder (unaffiliated), Nicole Joseph (unaffiliated), Sarah Ives (Mentoring), Pia Damonte (Admin), and Jaspreet Sandha (Admin).

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) update RAC members, new and "veteran," on RAC efforts over the past year, (2) develop specific interventions based on collected data, and (3) determine which RAC members would commit to future tasks. The group performed an analysis of both qualitative and quantitative data from the November survey with two goals: (1) ensure that resulting interventions would be consistent with data collected, and (2) to set the stage to develop intervention(s) targeting professional learning and support for early career teachers. The group distilled themes and questions from the survey to identify possible interventions for bolstering professional learning and support of early career teachers. The group also agreed that due to time constraints, the administration of future surveys would not be needed to further define Plan-Do-Study-Act (PDSA) cycle interventions. During RAC work time, a number of topics were discussed that further defined potential RAC interventions, including: (1) compensation for participating educators for participating in interventions, (2) how retention connects to improved student learning and can this be measured, and (3) the potential of using (online) school-district-level informational meetings with administrators and/or other teachers to highlight retention issues (e.g. placement).

Additionally, the group reviewed a "mock" 10-minute meeting intervention devised by one of the RAC leaders (Martinez), which was piloted in May with an early career teacher and principal at the public Pacifica High School in Oxnard, California. Verbal responses were provided with the overall consensus that the intervention idea had merit and could be used to support the STRIDES goals. The STRIDES RAC group ended its collaborative work by defining a research question that would encompass its efforts: How does targeted, interpersonal support by on-site, instructional leaders impact retention of early career secondary mathematics teachers? A final effort at the meeting was accomplished by splitting into self-selected sub-groups to flesh out interventions in three areas: (1) mentoring of early career teachers, (2) support for administrators to support early career teachers, and (3) determination of possible funding for continued work.

Table 1

Summary of future RAC work

FOCUS AREA	DESCRIPTION	WHAT WE WANT TO LEARN
ROLE OF ADMINISTRATORS	Support administrators by creating a common vision and using strategies to reinforce retention of early career mathematics educators.	*What targeted supports for administrators impact teacher retention?*
TRAINING & SUPPORTING TEACHER MENTORS BY SITE-BASED COLLEAGUES	Does training mentors affect teacher retention?	*How can mentors support early career teachers?*
FUNDING SOURCES	Determination of funding sources for continued work for STRIDES	*What sources of funding are available and applicable to the STRIDES work? What are applicable dates for submittals and which STRIDES member(s) will be working on this?*

At the conclusion of the work sessions, Dr. John Sutton, a senior researcher associate from RMC Research, spoke to the group about his work as grant evaluator and facilitator of Noyce grants, which he performs for other RACs and non-MTE-Partnership groups. He offered his services to the STRIDES RAC should we need him in the future.

Conclusion

The STRIDES RAC was fortunate to incorporate into its work important ideas expressed during non-work time sessions at the conference, specifically with regard to social justice/equity and transformations. STRIDES was able to recruit a number of new members who serve their institutions in a wide range of capacities (mathematicians, math educators, and school district representatives). They, along with “veteran” members, contributed significantly to the ongoing efforts of the RAC. “Work time” was efficient and relatively productive, achieving about half the goals originally stated for the conference. A good amount of work time was devoted to re-evaluating the results of the November 2016 survey to ensure that future interventions would adequately address the needs expressed by the survey participants. The decision was made to restrict the interventions to two areas: on-site mentoring and support for administrators. A vital task was accomplished in defining the STRIDES RAC research question; unfortunately, very little time could be dedicated to specifically define interventions (defined as part of individual PDSA cycles). This work will need to be assigned to individual RAC members in two “sub-RACs” and completed collaboratively. Finally, defining which local/state/federal/private grants can be used to support the STRIDES RAC goals was also only superficially addressed, requiring additional efforts by RAC members. Leaders of the STRIDES RAC will be holding a teleconference on August 11, 2017 to determine next steps, which will be communicated to all RAC members.

References

Fantilli, R.D., & McDougall, D. E. (2009). A study of novice teacher challenges and supports in the first years. *Teaching and Teacher Education, 25*, 814-825.

Foster, E. (2010). *How boomers can contribute to student success: Emerging encore career opportunities in K-12 education*. Washington, DC: National Commission on Teaching and America's Future.

Goldring, R., Taie, S., & Riddles, M. (2014). *Teacher attrition and mobility: Results from the 2012-13 teacher follow-up survey (NCES 2014-077).* U.S. Department of Education. Washington, DC: National Center for Education Statistics. Retrieved from http://nces.ed.gov/pubsearch

Mehta, J., Theisen-Homer, V., Braslow, D., & Lopatin, A. (2015). *From quicksand to solid ground: Building a foundation to support quality teaching*. Retrieved from http://www.totransformteaching.org/wp-content/uploads/2015/10/From-Quicksand-to- Solid-Ground-Building-a-Foundation-to-Support-Quality-Teaching.pdf

National Math + Science Initiative (2013). *STEM education statistics*. Retrieved from https://www.nms.org/AboutNMSI/TheSTEMCrisis/STEMEducationStatistics.aspx.

Equity & Social Justice Working Group

Brian R. Lawler, Kennesaw State University, blaw@kennesaw.edu

Frederick Uy, California State University, Los Angeles, fuy@calstatela.edu

The formation of an Equity and Social Justice Working Group (E&SJWG) was approved at the January 2017 Planning Committee meeting, which launched a call to current Research Action Cluster (RAC) leadership to solicit working group members. The goal for this group was set "to establish a foundation for better incorporating equity work into the Mathematics Teacher Education Partnership (MTE-Partnership)." Those nominated and agreed to serve can be found in Table 1.

Table 1

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

Cyndi Edgington, North Carolina State University	Julie McNamara, California State University East Bay
Angie Hodge, University of Nebraska – Omaha	Farshid Safi, University of Central Florida
Ryan Seth Jones, Middle Tennessee State University	Ruthmae Sears, University of South Florida
Brian R. Lawler, Kennesaw State University	Jamalee Stone, Black Hills State University
Josh Males, Lincoln Public Schools	Marilyn Strutchens, Auburn University
Lorraine M. Males, University of Nebraska – Lincoln	Frederick Uy, California State University Los Angeles
Charmaine Mangram, University of Hawai´i at Mānoa	

The working group first came together via conference call on March 22, 2017, then again on May 3, 2017. These calls served to: organize the group, set a purpose, review the MTE-Partnership's *Guiding Principles* (2014), and begin generating ideas about what would be described eventually as the problem space and aim of the RACs, should one develop from the working group. During the first conference call, the group collected research on equity issues in mathematics education, information about successful programs, and policy and standard documents. The second call involved planning for the equity elements of the conference and the working group meeting in the days after. The call also included the idea to develop an advisory panel to the future Equity RAC to provide perspective. And members all agreed to ask a district partner: "What challenges do you see in the preparation of secondary mathematics teachers especially related to equity?"

Discussion Forum

The E&SJWG organized an evening discussion on Monday, June 26, 2017, and then met for two half-days after the MTE-Partnership conference, June 27-28, 2017. The evening discussion was organized due to the large participation at a similar event at the 2016 conference. Drs. Strutchens and Lawler opened the discussion with a brief review of the role of equity issues in the MTE-Partnership. The *Guiding Principles* (2014) offered several principles focused specifically on challenges related to equity:

> *Guiding Principle 5-E Attention to Diversity:* The teacher preparation program ensures that teacher candidates recognize that all students in their classes… have the potential to make important contributions, and that they maintain high expectations for all students.

Guiding Principle 6-C Sense of Justice: The teacher preparation program fosters a sense of agency in its teacher candidates so that through their actions, behaviors, and advocacy, candidates demonstrate a dedication to equitable pedagogy that promotes democratic principles by holding high expectations for all students, while recognizing and honoring their diversity.

Guiding Principle 7-D Promoting Diversity in Teacher Candidates: The mathematics teacher education program actively recruits teacher candidates representative of the broad diversity of students who they will teach and provides them with the support necessary for their success.

The members also recognized the work of the current RACs that aligned specifically with these principles, specifically:

- *Clinical Experiences:* training for use of $MCOP^2$ to create match between university and district expectations for mathematics instruction
- *Active Learning Mathematics:* use of $MCOP^2$ to measure equitable learning experiences
- *Program Recruitment and Retention:* recognizing the challenge to account for diversity
- *STRIDES:* attending to the issues of retaining our well-prepared teachers, in many cases when they are hired to schools not well-aligned to their preparation

Although most RACs were currently addressing equity issues in some manner, the Planning Committee has wondered (since January 2016) if expecting equity issues to be managed in each of the RACs was sufficient, or if a specific and focused effort was also necessary.

This question was put to the community during a discussion forum at the 2016 MTE-Partnership Conference in Atlanta, GA. From that forum, a working group was strongly recommended, with the aim of developing into a RAC. The RAC would generate solutions to the equity challenges as laid forth in the Guiding Principles. Further, the community asked the RAC to function in a way that would inform the other RACS on elements of their work that they had less expertise on. Also during the 2016 conference discussion, more refined equity issues were raised, such as a need to carefully define Equity, Diversity, Social Justice, and similar terms; to be wary that some research were showing that teacher candidate's beliefs and biases could harden in the effort to teach equity topics; to examine how privilege and power were intertwined in these challenges; and to examine and respond to how broader structures impacted equity in mathematics education. One example given was the current trend toward resegregation of K-12 schools.

In addition to the refined equity issues that emerged in Atlanta, the Association of Mathematics Teacher Educators (AMTE) has released *Standards for Preparing Teachers of Mathematics* (2017) further pressing the challenge of ensuring each and every secondary mathematics teacher candidate is well prepared. In these standards, they define as their first assumption, "Ensuring the success of each and every learner requires a deep, integrated focus on equity in every program that prepares teachers of mathematics" (p. 1), much in line with the charge emerging from the Atlanta discussion forum. Specific standards added to the nuance, and challenge:

Standard C.2: 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' sense making, understanding, and reasoning.

Standard C.4: 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.

Each AMTE Standard has several indicators, providing specific direction. For example, Indicator C.4.2. calls for "well-prepared beginning teachers of mathematics recognize that their roles are to cultivate positive mathematical identities with their students" (p. 21). And Indicator C.4.4. calls for mathematics teachers to understand the roles of privilege and power in the history of oppression in mathematics education, and to equip future teachers "to question existing educational systems that produce inequitable learning experiences and outcomes for students" (p. 23).

Having laid out some of the context for the discussion and recalling the Equity Panel from earlier in the day, Drs. Strutchens and Lawler directed table groups to consider:

- What challenge do these standards identify for MTE-Partnership's goal to create the gold standard for secondary mathematics teacher preparation?
- If possible, identify a solution, strategy, or resource that may help us (MTE-Partnership community) achieve that aim.

Table groups were asked to record ideas to notecards as they talked. These notecards were brought to the working group meeting in the day after the conference to contribute to the work to define the problem space. Specific challenges that were shared out to the whole group included:

- Cohorts tend to be homogeneously White and middle class, making it difficult to talk about issues surrounding race and wealth.
- The culture of the teacher will not match the culture of the students.
- The standard text books pay lip service at best to diversity/equity (changing names).
- A need to get more minority college students to consider education as a career which also means getting them to take higher level math courses which requires more exposure to higher math in high school which requires more equity. Quite the cycle.
- Typical field experiences don't always align with the teaching practices that are valued in methods courses, making it difficult to 1) reinforce those practices, and 2) shed further light on how those practices may help reduce inequities.
- The myth that math is neutral toward culture
- Building a stance that recognizes/values/leverages students assets & initial conceptions including those rooted in cultural traditions/experiences, but avoids the white savior/missionary syndrome
- Tracking and all of the issues surrounding it
- The perception of smart & dumb kids

Neither strategies nor resources were shared at this time, and few were recorded in the notecards. It was evident that the collective state of at least this group of mathematics educators was to recognize the complexity of the problem, and that the members did not yet have solutions.

The final segment of the discussion forum was for RAC teams to gather, review their drivers, and draw connections to the challenges of the previous discussion, including those identified in conversation, the *Guiding Principles* (MTE-Partnership, 2014), and the *AMTE Standards* (2017). With the topics they found among those connections, RACs were to sort them into three groups: *we're actively working on, we ought to be working on, and uncertain we could work on*. Each RAC team reported their responses on a poster to close the evening; these are presented in Table 2.

Table 2

Team self-analysis of current state of equity work within their RAC.

RAC	Actively Working On	Ought to be Working On	Uncertain we Could Work On
Program Recruitment & Retention	• Recruitment strategies • Outreach • Advising/support • Defining equity, diversity, social justice	• Identify characteristics of a "strong candidate" • Identify characteristics of a "strong" mentor/cooperating teacher (CT) • How to grow CT? • Connections to STRIDES • Policy advocacy	• Things that are highly context dependent
Clinical	• Engaging students in equity discussions	• Include equity in syllabus • Incorporate equity into each lesson • Social justice? – define critical components • Review our program assessments • How to empower students in the classroom	
MODULE(S)[2]	• Address social (in)justice through context • Engaging in the Standards of Mathematical Practices promotes equity in the classroom • Include information about equitable teaching practices in the instructor guides • Attend to diversity in the teaching examples provided in the materials (e.g. mathematical ideas come from students of diverse backgrounds)		
Active Learning	• MCOP²+ • Consistency of implementation, disrupt cultural reproduction	• Position documents and bring to math faculty (political will) • Students' culture reflected in the curriculum • Support students without tracking	• Retention of preservice after P2C2
STRIDES	• Retain through mentoring, developing PLCs, fostering connection and dialogue • Attract, nurture, and graduate high quality math teachers who are representative of diverse communities	• Connection, fit, and coherence	

Working Group

The members of the formal working group gathered after the conference, from Tuesday afternoon until Wednesday noon, joined by several interested guests, including: Keisha Albritton (South Florida), Belinda Edwards (Kennesaw State), Mark Ellis (CSU Fullerton), Nancy Kress (Colorado), Gary Martin (Auburn), and Wendy Sanchez (Kennesaw State). During the two half-days, the goal was to begin to develop the problem space, aim, and driver diagram for the RAC that would emerge. On Tuesday afternoon, the focus was to lay out the problem space. The group began by reviewing the goal for the E&SJWG, "to establish a foundation for better incorporating equity work into the MTE-Partnership," and brainstormed to sticky notes "what are the major challenges that are impeding progress toward this goal?"

The members posted these ideas to the wall, and organized them into related clusters, allowing the group to identify the major challenges impeding progress toward the goal. The next step was a sort of triangulation, to consider how the brainstorming agreed with work already done, and what might that work suggests needs to be added. The group examined input from a variety of sources, including that from the Equity Discussion Forum the previous day, our own work in conference calls and from homework, and the responses from the 2016 Equity Discussion (Lawler & Strutchens, 2016), reproduced in Table 3. This led to some refinements, specifically an effort to create an evocative title for the cluster and a way to organize the ideas within. This work led to a *fishbone diagram*—a visual image of these ideas that help to lay out the problem space (Figure 1). Participants were charged to consider a possible "aim" for E&SJWG, which was to be measurable and include a time limit.

The group continued on Day 2 with a review of the ideas generated for the aim. Three themes were evident in the aims the group generated: beliefs, resources, and outcomes. It was agreed that the aim should focus on identity, to increase (or grow) pre-service secondary mathematics teachers' positive Sociopolitical Mathematics Teacher Identity. The sort of identity should include a definition of equity, for whom; move toward action, not just about beliefs; becoming advocates for their students; and understanding the importance of equitable teaching practices. A measure, which might define a trajectory, needed to be developed, while the aim needed refinement responding to the measure, and setting a timeline. This selection was made in part because of the strong alignment to *Guiding Principle 6-C: Sense of Justice*, a core part of the mathematics teacher identity.

From this aim, the primary drivers were next considered. We first considered the context: What institutions/organizational units/players are involved in this problem? And what organizational features are most critical? From this conversation, individually we identified general areas that the RAC might target to reach its aim? These were recorded to sticky notes, which were then posted and clustered. The clusters were named as possible primary drivers, and the ideas under them were sorted to identify potential secondary drivers, potential key levers for productive change. The categories that emerged for possible primary drivers were: experiences and beliefs, strategies for pre-service teachers, mathematics teacher educator resources, measures, policy, partners and stakeholders, and other RACs.

A break from the morning agenda was taken to tease out definitions for equity, diversity, and social justice. Three workgroups were formed; each began with definitions started by the PR2 RAC, and built upon with definitions by other agencies and authors. This project would be taken by a subcommittee, with a draft to be presented to the MTE-Partnership community at the 2018 conference.

Table 3

Responses to table discussions about issues related to equity and social justice that are important for the preparation of secondary mathematics teachers

Category with responses from the working group
Children's mathematical identities
Mathematical identity (e.g. *Do children see themselves in curriculum?)*
What teacher actions cause positive or negative mathematics identities?
Better ways to assess mathematical potential, such as in early college experience
Mathematics teacher identities
Teaching mathematics is a sociopolitical act
Empower candidates to be agents of change
Maintain candidates' confidence in mathematical abilities as they take higher mathematics
Biases in the discourse about people and mathematics
Discourse (how people interact and the expectations they have for one another)
Preservice teacher awareness of deficit language, discourses, and practices
Deficit language among ourselves as Mathematics Teacher Educators (MTE)
MTE biases and beliefs, such as how we perceive students, or who should have access
Stereotype threat, for both faculty and preservice teachers
Biases in the structures around mathematics education
Tracking
Integration of diversity, equity, and social justice specifically to mathematics and specific domains
Institutional racism
Challenges to recruitment
Discouraging messages against becoming a teacher
Clinical experiences could attend to equity and social justice with equal importance to mathematics instruction
Structural challenges to recruitment that eliminate potentially good candidates, such as advising and some standardized tests (related to cultural capital)
Broadened participation to match local population (maybe recruiting earlier can help)

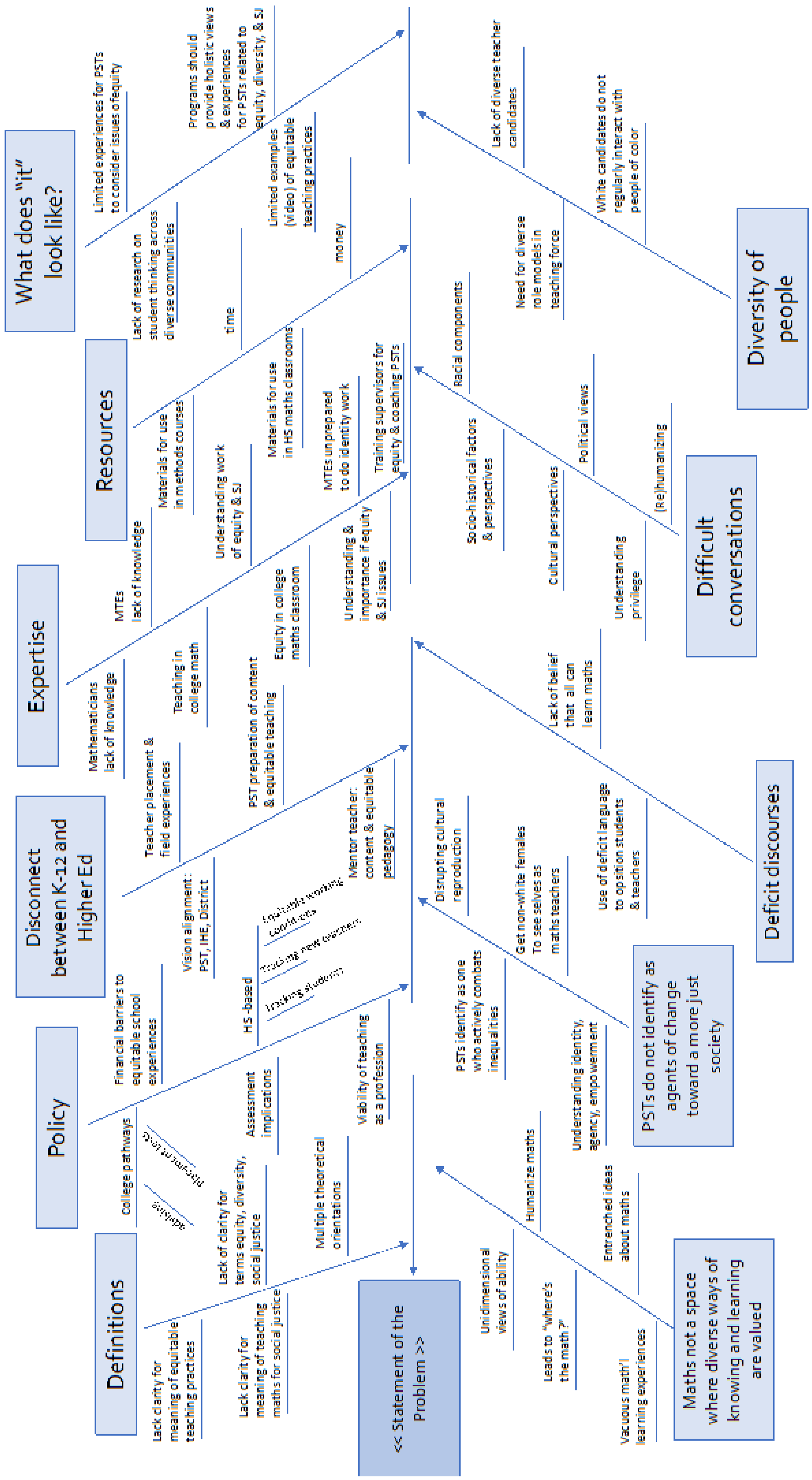


Figure 1. Fishbone diagram, identifying the major challenges toward the E&SJWG goal.

The meeting of the working group closed by identifying October 27-29, 2017, as a follow-up gathering to refine the items worked on here, and take next steps, such as a thorough review of relevant literature and development of measures. One group would work to create a first draft of definitions for each term equity, diversity, and social justice. And a second group would work to draft a Driver Diagram. The goal was to create a thorough proposal to the MTE-Partnership community for ratification of the Equity & Social Justice RAC at the 2018 MTE-Partnership Conference.

References

Association of Mathematics Teacher Educators. (2017). *Standards for preparing teachers of mathematics.* Raleigh, NC. Available online at http://amte.net/standards

Lawler, B.R., & Strutchens, M. (2016). Pre-session on equity and social justice. In B. R. Lawler, R. N. Ronau, & M. J. Mohr-Schroeder (Eds.), *Proceedings of the Fifth Annual Mathematics Teacher Education Partnership conference*. Washington, DC: Association of Public Land-grant Universities.

Mathematics Teacher Education Partnership. (2014). *Guiding principles for secondary mathematics teacher preparation*. Washington, DC: Association of Public Land Grant Universities. Retrieved from http://www.aplu.org/projects-and-initiatives/stem-education/SMTI_Library/mte-partnership-guiding-principles-for-secondary-mathematics-teacher-preparation-programs/file

Transformations Working Group

W. Gary Martin, Auburn University, martiwg@auburn.edu

and the Transformations Working Group

From its inception, the Mathematics Teacher Education Partnership (MTE-Partnership) has had as its goal "transforming secondary mathematics teacher preparation" in alignment with the Common Core State Standards and other rigorous standards. As the MTE-Partnership subsequently adapted the Networked Improvement Community (NIC) design (Bryk et al., 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 (Bryk, et al., 2015, p. 141). This, 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 integrate the work of the partnership across multiple RACs. However, accomplishing this will in many cases raises 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 Working Group began its work at a meeting directly following the 2016 MTE-Partnership Conference. It met again in November 2016 and May 2017 and also held several conference calls. During these meetings, the group has explored the literature on institutional change (e.g., Corbol et al., 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. Note that the Association of Mathematics Teacher Educators' (2017) *Standards for preparing teachers of mathematics* reiterates many of the conclusions reached by the Working Group.

Table 1

Transformation Working Group Members

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
Robin Hill, Kentucky Department of Education	Daniel Reinholz, San Diego State University
Judy Kysh, San Francisco State University	Wendy Smith, University of Nebraska-Lincoln
Alyson Lischka, Middle Tennessee State University	Marilyn Strutchens, Auburn University
W. Gary Martin, Auburn University	Diana Suddreth, Utah State Office of Education

Proposal for Formation of a Transformations RAC

The initial work of the Working Group resulted in a proposal to form a new RAC. The proposed RAC includes attention to the MTE-Partnership primary driver, Creating a Vision. However, the partnership driver diagram may need to be revisited to better accommodate the new emphasis on program transformation. A key issue is that transformation efforts need to "see the system": considering all the components of teacher preparation, including people (pre-service teachers, K-12 teachers, K-12 administrators, university faculty, university administrators, state-level policymakers); interactions among people; institutions (colleges, K-12 schools); and the community. Transformation efforts need to understand how the local contexts together produced or perpetuate the current system before attempting to improve the system. A first draft of a revised MTE-Partnership driver diagram is provided in Figure 1, which proposes a new primary driver focusing on transformation that overarches the other primary drivers.

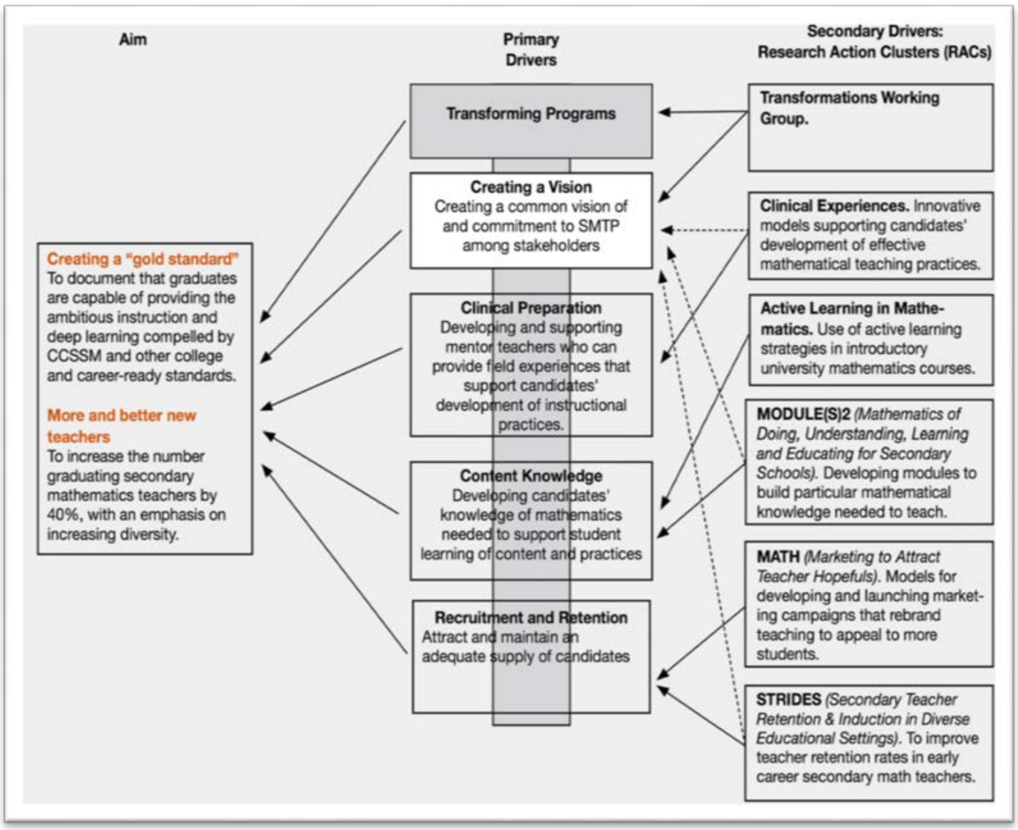
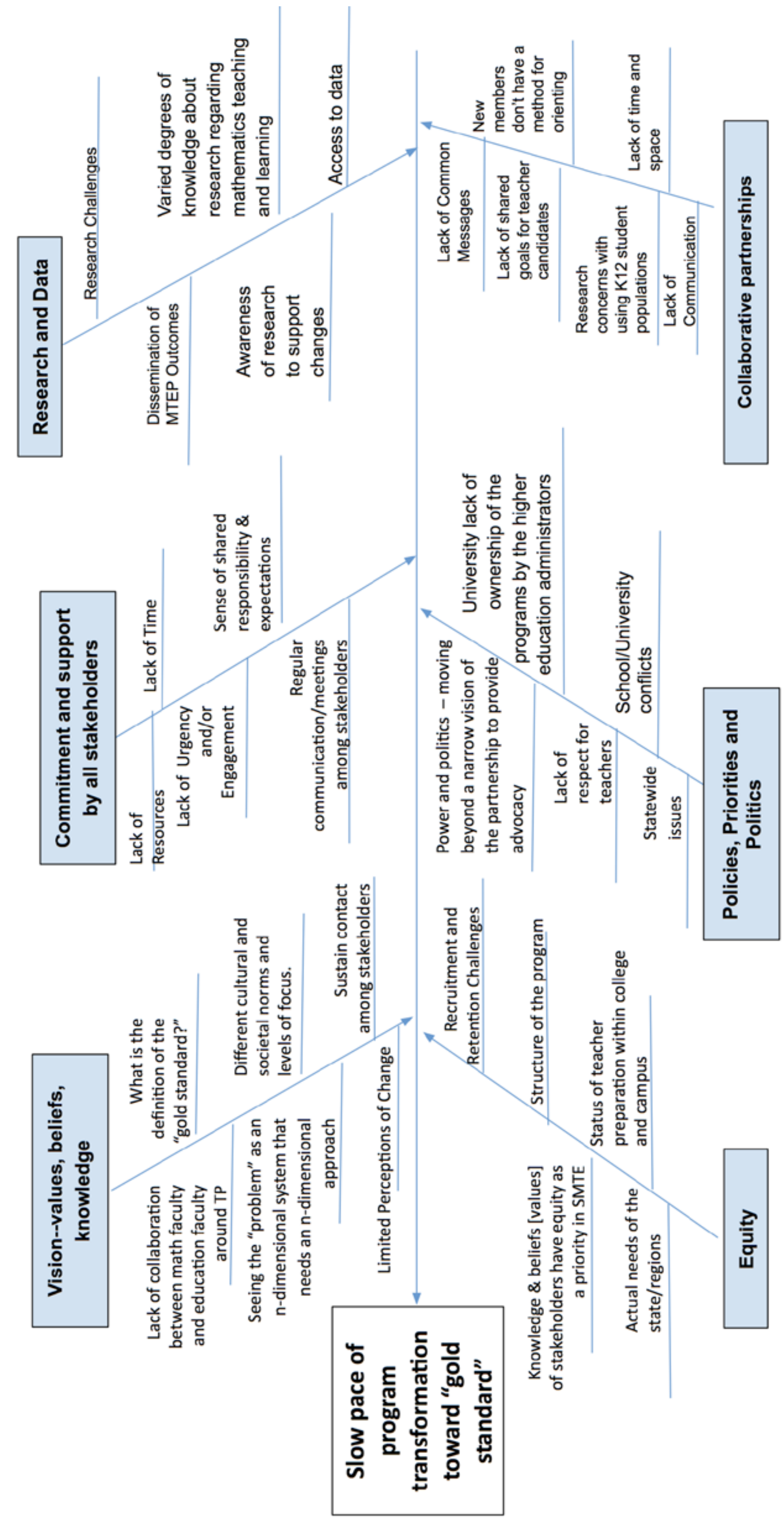


Figure 1. Proposed revision to the MTE-Partnership driver diagram.

Analysis of the Problem. Based on multiple discussions and data sources (including a recent survey of MTE-Partnership teams), problems and subproblems that impede progress toward program transformation were identified and organized into a fishbone diagram, given in Figure 2. A fishbone diagram is a tool that visually represents a group's causal systems analysis (sometimes known as a cause-and-effect diagram or Ishikawa diagram) (see https://www.carnegiefoundation.org/resources/learning-to-improve-glossary/ for more information).



Note: TP=Teacher Preparation; SMTE=Secondary Math Teacher Education

Figure 2. Fishbone diagram representing the problem space for program transformation in secondary mathematics teacher preparation.

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 the 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, fieldwork with mentor teachers in partner school districts, to early career induction support.
- In order 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 the new *Standards for the Preparation of Teacher of Mathematics* from the Association of Mathematics Teacher Educations; see www.amte.net/standards .
- "N" will initially be somewhat small (perhaps 10), 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 3. 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 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).

Next Steps

The Transformation Working Group provided two opportunities to engage teams in discussion about program transformation at the 2017 MTE-Partnership Conference:

1. During the working dinner following the opening keynote address addressing networked communities, teams were presented with a series of structured questions to help team members to explore their current context.
2. 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 groups and prospects for participation in program transformation as a part of the proposed Transformational Change Research Action Cluster (RAC).

Based on the feedback at the conference, the Working Group will devise and implement a process for teams to apply to join the RAC, tentatively in Fall 2017. In addition, members of the subgroup will be working to develop a white paper outlining relevant research and analysis underlying the development of the RAC.

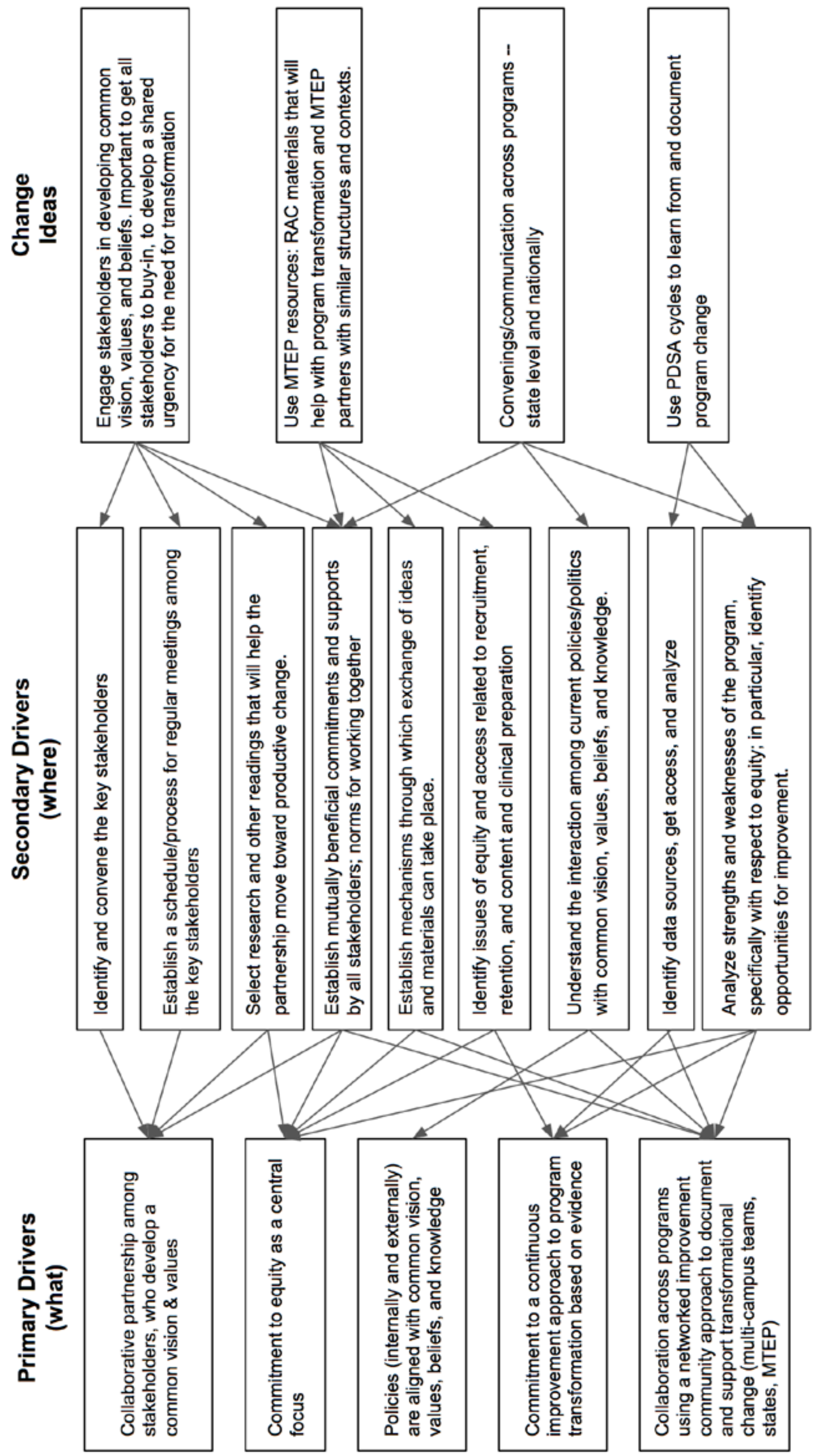


Figure 3. Driver diagram to guide progress toward the aim of program transformation.

References

Association of Mathematics Teacher Education. (2017). *Standards for preparing teachers of mathematics*. Raleigh, NC: Author.

Bryk, A., Gomez, L. M., Grunow, A., & LeMahieu, P. (2015). *Learning to improve: How America's schools can get better at getting better*. Cambridge, MA: Harvard Education Press.

Corbo, J. C., Reinholz, D. L., Dancy, M. H., Deetz, S., & Finkelstein, N. (2016). Framework for transforming departmental culture to support educational innovation. *Physical Review Physics Education Research*, *12*(1), 010113.

Elrod, S., & Kezar, A. (2016). *Increasing student success in STEM: A guide to systemic institutional change.* Washington, DC: Association of American Colleges & Universities.

Research Presentations

Introducing Mathematical Literacy PDSAs into a Partnership Team

Scott A. Courtney, Kent State University, scourtn5@kent.edu

Abstract

The 2016 presidential election campaigns and post-election dissonance has highlighted the need to reflect on what are taken as reliable (sources) and valid (facts, data). In what has been labeled the "post-fact" age, truth and what constitutes as truth have become daily talking points. Differences in peoples' perspectives relate, in part, to where they receive their news and information (e.g., CNN, Fox News). Individuals also receive news and information, socially, from a variety of sources, including Facebook, Twitter, Reddit, or face-to-face; each of which add their own nuances to how items are interpreted. Mathematical Literacy provides a means to confront "fake news," "alternative facts," and non-factual thinking, reasoning, and decision-making by focusing on meanings (i.e., understandings) and how each of us: makes sense of and interprets data, reasons, constructs arguments, responds to the arguments of others, explores the validity of our own and others' conjectures and conclusions, and receives and disseminates information. This report describes one team's efforts to integrate Mathematical Literacy into its work with pre-service and in-service math teachers and math intervention specialists. Using PDSA cycles, the team works to support teachers' establishment of professional learning communities and continued professional growth, and engage local institutions (universities, school districts, city officials, businesses, PTA, residents) in transformational stewardship and leadership. Working with colleagues in other subject areas (e.g., language arts, social studies), the team assists citizens, including Grades 6-12 students, identify reliable and valid data and sources, make sense of and interpret data, reason, construct arguments, and explore the validity of one's own and others' conjectures and conclusions.

Keywords: reasoning and sense making, data interpretation, Mathematical Literacy, institutional transformation

Introduction

The 2016 presidential election campaigns and post-election dissonance has highlighted the need to reflect on what are taken as valid (facts, data) and reliable (sources). In what has been labeled the "post-fact" age, truth and what constitutes as truth have become daily talking points (Drezner, 2016; Flood, 2016; Heer, 2015; Kurtzleben, 2017; Pazzanese, 2016; Slack, 2017). Differences in peoples' views and perspectives relate (in part) to where they receive their news and information. Such distinctions arise (in part) from praise and criticism leveled by or at President Trump throughout his campaign and presidency, such as: Fox News, The Rush Limbaugh Show, InfoWars, Breitbart News, New York Post, and the so-called "mainstream" media (e.g., ABC, CBS, CNN, and NBC News; New York Times; Washington Post). Individuals also receive news and information, socially, from a variety of sources, each of which add their own nuances to how items might be interpreted: Facebook, Twitter, Instagram, Pinterest, Reddit, Tumblr, YouTube, texting, and face-to-face. With all of these filters, how do we begin to think of one another as simply having different points of view, but all being concerned citizens wanting a healthy America and planet?

Since 2015, the Kent State University Mathematics Teacher Education Partnership (KSU-MTE-Partnership) has struggled to retain its membership in the larger MTE-Partnership with the dissolution of the Knowledge-for-Teaching-Mathematics Tasks (KTMT) Research Action Cluster (RAC)—in essence, leaving KSU-MTE-Partnership "RAC-less." KSU-MTE-Partnership views Mathematical Literacy as a bridge to not only foster its increased presence in MTE-Partnership, but also to promote the tenets of Guiding Principle 6, Professionalism, Advocacy, and Leadership (MTE-Partnership, 2014). In particular, through its focus on Mathematical Literacy, KSU-MTE-Partnership advances Guiding Principle 6 by modeling and promoting actions that are "ethical, open, honest, and forthright," and "democratic principles . . . [exhibiting] high expectations for *all* students, while recognizing and honoring their diversity" [authors' italics] (p. 5).

As such, Mathematical Literacy provides a means to confront "fake news," "alternative facts," and non-factual thinking, reasoning, and decision-making, by focusing on meanings (i.e., understandings) and how each of us makes sense of and interprets data, reasons, constructs arguments, responds to the arguments of others, explores the validity of our own and others' conjectures and conclusions, and receives and disseminates information. The definition for Mathematical Literacy most aligned with that employed by KSU-MTE-Partnership comes from the Organisation for Economic Co-operation and Development (OECD):

> Mathematical Literacy is an individual's capacity to formulate, employ, and interpret mathematics in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognize the role that mathematics plays in the world and to make the well-founded judgments and decisions needed by constructive, engaged and reflective citizens. (OECD, 2016, p. 28)

Mathematical Literacy, as conceived of and employed by KSU-MTE-Partnership, aligns with aspects of work being done by the Equity Working Group and the Transformations Working Group. In addition, KSU-MTE-Partnership's vision of Mathematical Literacy intersects with multiple RACS (e.g., Active Learning Mathematics) and the larger Mathematics Teacher Education Partnership.

Methods

Over the past nine months, KSU-MTE-Partnership has begun integrating Mathematical Literacy ideas into pre-service courses and in-service professional development. Such work has allowed for the exploration of data and resources with likeminded and non-likeminded individuals and created spaces for mindful discourse. Furthermore, mindful discussions allow for the potential to build consensus among ideas through mutual concessions, provided there is a focus on meanings.

Meanings are the substance of thinking and reasoning. As such, the meanings (i.e., understandings) we think with, reason with, converse with, and debate with are critical. In order to have any clear idea what we are thinking about, communicating about, reasoning with and about, debating about, presenting to others, we need to: (1) articulate our meanings to ourselves, (2) articulate our meanings to others, and (3) expect others to do the same. Therefore, making clear how you understand ideas, concepts, and issues and asking others to do the same is critical—and perhaps so self-evident we rarely do it—in any discussion regarding: mathematics, science, language arts, social studies, finance, politics, technology, education, poverty, taxes, mental health, domestic violence, hate and extremism, etc.

KSU-MTE-Partnership relies on the Plan-Do-Study-Act (PDSA) cycle—a core improvement science principle—allowing for rapid cycles of learning from practice at small scale to study the impacts Mathematical Literacy has on pre-service teachers, in-service teachers, and their students (Bryk, Gomez, & Grunow, 2015; Lewis, 2015). In addition, KSU-MTE-Partnership partners with educators in other subject areas (e.g., social studies, science, journalism) and local officials and parent organizations (e.g., PTA) to enhance and broaden the impact of its work. Some of the areas KSU-MTE-Partnership has focused on are described below.

Polls and Polling

In addition to working with teachers and students to productively interpret and create polls and surveys, instruction (and professional development) focuses on addressing the following questions: What is a sample? If N is the number of people polled, is it all right for N to vary for each poll? Why does N sometimes involve adults nationwide and sometimes registered voters nationwide? What is a "margin of error"? How do polling organizations determine whom to poll? Do poll organizations ask their questions online, by phone, or in-person, and does it matter? Who pays for these polls? Why aren't more people polled? How do we know people aren't lying when they answer poll questions?

Representation and Voting

KSU-MTE-Partnership involves teachers and their students in exploration and examination of Democratic and Republican congressional member demographics compared to national, state, and congressional district demographics (e.g., percent female, Hispanic, Veteran, foreign born, with a disability, LGBTQ). Such instruction leads to examination of data involving and discussions around: voter turnout, voter identification, voter suppression, congressional offices, and congressional district gerrymandering.

Data Resources

KSU-MTE-Partnership works with pre-service and in-service teachers to integrate data into their lessons in authentic ways. Using easily accessible data from a variety of sources (e.g., U.S. Census Bureau, National Center for Education Statistics, United Nations, World Health Organization, National Center for Health Statistics, Bureau of Labor Statistics) and various representation tools (e.g., Gapminder, Excel, GeoGebra, Desmos), KSU-MTE-Partnership helps teachers focus lessons on discussions around data validity, interpretation, dissemination, and extrapolation.

Conclusion

KSU-MTE-Partnership believes a re-focused grassroots effort should be placed on Mathematical Literacy. Furthermore, we believe the MTE-Partnership can be a driving force in making such an effort practicable. Mathematics teachers (at all grade levels, including mathematics teacher educators) can assist their fellow citizens (from all age groups) determine where to find reliable and valid facts, data and sources. Mathematics teachers can use their content and pedagogical expertise to help others make sense of and interpret data, reason, construct arguments, respond to the argument of others, and explore the validity of one's own and others' conjectures and conclusions.

Furthermore, efforts should be expanded by: (1) integrating the work of mathematics educators with educators and organizations from other disciplines (e.g., sociology, public health, journalism, U.S. government, contemporary world issues, technology, social justice studies, environmental studies, constitutional law, criminology, and business), and (2) developing partnerships among schools, districts, universities, parents and parent organizations, local and federal officials, the media, and charitable organizations. Such integrated partnerships can serve as Networked Improvement Communities (NIC) that work together to understand and confront a variety of data-informed issues, where "confront" means mindfully discussing each issue and coming to consensus through mutual concessions.

We are by no means claiming Mathematical Literacy and a focus on meanings is a panacea to heal all of the issues and polarization that currently trouble America. But, as characterized by Bertrand Russell (1919), "Mathematics, rightly viewed, possesses not only truth, but supreme beauty" (p. 60). KSU-MTE-Partnership believes everyone would agree we need a little truth and beauty in America right now.

For More Information

- Website: Re-Making the Case for Mathematical Literacy https://scourtn5.wixsite.com/meaningsmatterml
- Contact: Dr. Scott Courtney at Kent State University (scourtn5@kent.edu)

References

Bryk A. S., Gomez L. M., & Grunow A. (2010). *Getting ideas into action: Building networked improvement communities in education*. Stanford, CA: Carnegie Foundation for the Advancement of Teaching. Retrieved from https://www.carnegiefoundation.org/wp-content/uploads/2014/09/bryk-gomez_building-nics-education.pdf

Drezner, D. (June 16, 2016). Why the post-truth political era might be around for a while. *The Washington Post*. Retrieved from https://www.washingtonpost.com/posteverything/wp/2016/06/16/why-the-post-truth-political-era-might-be-around-for-a-while/?utm_term=.53c19fc9abfc

Flood, A. (November 15, 2016). 'Post-truth' named word of the year by Oxford Dictionaries. *The Guardian*. Retrieved from https://www.theguardian.com/books/2016/nov/15/post-truth-named-word-of-the-year-by-oxford-dictionaries

Heer, J. (December 1, 2015). Donald Trump is not a liar. *New Republic*. Retrieved from https://newrepublic.com/article/124803/donald-trump-not-liar

Kurtzleben, D. (February 23, 2017). Voters trust the media more than Trump... maybe. Retrieved from http://www.npr.org/2017/02/23/516845174/voters-trust-the-media-more-than-trump-maybe

Lewis, C. (2015). What is improvement science? Do we need it in education? *Educational Researcher*, *44*(1), 54-61.

Mathematics Teacher Education Partnership (MTE-Partnership). (October 16, 2014). *Guiding principles for secondary mathematics teacher preparation programs*. Washington, DC: APLU Science and Mathematics Teacher Imperative. Retrieved from http://www.aplu.org/projects-and-initiatives/stem-education/SMTI_Library/mte-partnership-guiding-principles-for-secondary-mathematics-teacher-preparation-programs/File

Organisation for Economic Co-operation and Development (OECD) (2016). *PISA 2015 results (Volume I): Excellence and equity in education*. Paris: PISA, OECD Publishing. http://dx.doi.org/10.1787/9789264266490-en

Pazzanese, C. (July 14, 2016). Politics in a 'post-truth' age. *Harvard Gazette*. Retrieved from http://news.harvard.edu/gazette/story/2016/07/politics-in-a-post-truth-age/

Russell, B. (1919). *Mysticism and logic: And other essays*. London: Longmans, Green and Company.

Slack, D. (February 16, 2017). 'Chaos.' 'Mess.' 'Fake news.' 'Turmoil.' Trump lets loose at press conference. *USA Today*. Retrieved from http://www.usatoday.com/story/news/politics/2017/02/16/president-trump-inherited-messes-washington-chaos/98000010/

Mathematical Autobiography as a Window into Sociopolitical Teacher Identity

Brian R. Lawler, Kennesaw State University, blaw@kennesaw.edu
Emma Carene Gargroetzi, Stanford University, egroetzi@stanford.edu

Abstract

This paper describes a study of sociopolitical mathematics teacher identity. Twelve prospective math teachers (PMTs) wrote multistage mathematics autobiographies (mathographies) in a mathematics methods course. We present an analysis of their narratives, making use of two distinct theoretical lenses, to consider how the PMTs may be negotiating emergent sociopolitical mathematics teacher identities. Implications for the preparation of mathematics teachers will be considered.

Keywords: mathematics teacher preparation, teacher identity

Introduction

Underlying the work of the Mathematics Teacher Education Partnership (MTE-Partnership) to improve the preparation of secondary mathematics teachers are numerous challenges that fall under the umbrella of "equity," such as recruitment and retention of a diverse pool of prospective mathematics teachers (PMTs) as well as preparing them in a manner that ensures they recognize that each and every student has the potential to make important mathematical contributions. A more complex challenge is articulated in the MTE-Partnership Guiding Principle 6-C (2014), "Sense of Justice: The teacher preparation program fosters a sense of agency in its teacher candidates so that through their actions, behaviors, and advocacy, candidates demonstrate a dedication to equitable pedagogy that promotes democratic principles by holding high expectations for all students, while recognizing and honoring their diversity." The recent AMTE Standards for Mathematics Teacher Preparation (2016) press further on the development of this sense of justice in Standard C.4, "Social Contexts of Mathematics Teaching and Learning" (p. 23), including an understanding of the roles of power, privilege, and oppression in the history of mathematics education. Related, the AMTE Standards also call for the PMTs to learn to support the development of positive mathematical identities within each one of their students. Mathematics teacher preparation is a key location for shifting the culture of mathematics teaching to attend to issues of equity, identity, and critical consciousness (Aguirre, Mayfield-Ingram, & Martin, 2013).

Equity issues such as these can be considered from a sociopolitical viewpoint (Gutiérrez, 2013; Mellin-Olsen, 1987), a perspective that examines the students produced by mathematics education, in which traditional dimensions of identity interact with agency, authority, and power. PMTs bring to their teacher preparation programs ideals and assumptions about education and mathematics, informed by both societal views and their own experiences in mathematics classrooms. Mathematics teacher educators that embrace sociopolitical goals often aim to disrupt these assumptions, to prepare PMTs with an awareness of themselves and their students as sociopolitical actors in a complex world. We call this orientation, when taken up as one's own, or, when sustained and performed over time, a sociopolitical mathematics teacher identity (Gargroetzi & Lawler, 2017).

In some teacher education courses, though in few mathematics methods courses, autobiographical projects are used to promote critical thinking and unearth ideological assumptions. The work produced through these projects can provide a window into the ways that PMTs are negotiating their emerging teacher identities. In this study, we examined how 12 secondary PMTs envisioned and articulated what it might mean to be, become, or act as a critically conscious mathematics teacher through an extended autobiographical writing project specifically attending to mathematics experiences, as both learners and teachers. Specifically, we sought to consider:

1. How are the PMTs negotiating emergent sociopolitical mathematical teacher identities, and
2. In what ways are they thinking about future students' mathematical identities?

Identity

Identity, as an analytic tool (Gee, 2000; Sfard & Prusak, 2005), provides a way to focus on the dialectical relationships between cognitive and social views on learning (Stentoft & Valero, 2009), possibly erasing the distinction. In critical mathematics education (CME) scholarship, identity, in both perspectives, is understood to inherently entail the negotiation of agency, authority, and power as it plays out both in and outside the classroom, and draws on social, cultural, and political discourses of both mathematics and belonging (Frankenstein, 1983). Sociopolitical approaches to mathematics education demand that we ask about the intersections of power and identity with learning and knowledge (Gutierrez, 2013). A sociopolitical mathematics teacher identity suggests a critical orientation to the work of teaching, schooling, and mathematics, recognizing that mathematics and schools produce people, even as they are simultaneously constructed by people. As such, a sociopolitical mathematics teacher identity entails, at least in part, attending to the emerging and performed mathematical identities (Aguirre, Mayfield-Ingram, & Martin, 2013) of one's own students.

The authors in this study situated themselves theoretically and analytically with two different approaches to identity, Positional and Post-Epistemological.[1] Gargroetzi takes a sociocultural and dialogic approach to identity, focusing specifically on positional identities. Positioning Theory (Davies & Harre, 1990) describes the construction of self as a negotiation of available "subject positions" and "storylines," often pre-existing. For example, all-knowing teacher and un-knowing student are two potential positions in the storyline of traditional classrooms. As individuals position themselves or are positioned by others toward available subject positions ("identities"), the ways in which they take up or reject those positions in turn shapes the positions subsequently available. Over time, repeated positionings may thicken into identification with certain positions and storylines over others, thus becoming a more sustained identity (Wortham, 2006). However, as with any discursively constructed position, these positions and identities are always open to disruption.

The use of Positioning Theory for inquiry into identity has been identified as appropriate to sociopolitical goals in the mathematics education research field in that it affords attention to both individual agency and pre-existing sociopolitical structures and brings together questions of identity and power (Herbel-Eisenmann, Wagner, Johnson, Suh, & Figueras, 2016; Langer-Osuna & Esmonde, 2016). For example, positioning theory allows one to consider whose positioning of whom is taken up, and whose is rejected? What pre-existing storylines, such as urban students as trouble-makers, or Asian students as good at math, make one positioning more likely than another? What are the rights and duties associated with each position, and what positions are made available in one context verses another? As PMTs position themselves and their students through their autobiographical

[1] Each perspective reflects a poststructural inclination. Positioning Theory, as drawn upon by Gargroetzi, aligns with the poststructural orientation to decenter the subject. The personal epistemology orientation Lawler develops aligns with the poststructural disruption of a realist ontology, problematizing the power relations bound up in the production of knowledge.

writing and reflection, they may articulate, accept, reject, and alter particular notions of what it means to be a math teacher, or to become or act as a sociopolitical mathematics teacher.

Lawler's interest in identity emerges from a constructivist's orientation to ontology, in which *viability* in an experiential world is substituted for the notion of *truth* in an experiencer-independent reality (von Glasersfeld, 1995). He is concerned with personal epistemology, an individual's beliefs about the nature of knowledge and knowing, including what knowledge is and how it is constructed. Specifically, Lawler's work investigates when and how a generative orientation to mathematics is sustained through adolescence while the broader sociocultural discourse seemingly works in opposition. While many adolescents seem to express a personal epistemology of *external authority* or *silence* (Belenky, Clinchy, Goldberger, & Tarule, 1986), Povey and Burton (1999) argue that the personal epistemology of *author/ity* may be a better target; it is an emancipatory identity. Rather than seeing the truth of mathematics as determined externally, to view oneself as not only the author of one's mathematics, but also the person who determines what is true or not speaks to the personal epistemology of author/ity. "If mathematics is understood as the 'telling of a story,' then each of us gains greater autonomy as an author of that mathematics, but not at the expense of a deep commitment to the social context of life and meaning making" (p. 236). That is to say, seeing oneself as an author of mathematical truths, suggests that one must recognize that each other person, like oneself, authors such truths as well. And for this reason, there is great commitment to and value of the other (Lawler, 2012).

A focus on author/ity, children as mathematical authors, resembles a discursive (poststructural) orientation to identity as characterized by Langer-Osuna and Esmonde (2016), but is distinctly poststructural in the attention to knowledge and identity as they are bound up and enacted in power relations among knowers, specifically in the mathematics classroom. Thus, personal epistemology, i.e. identity, is not the sum of multiple categorizations; rather, identity is discursive, negotiable, and thus fragile and dynamic, better characterized by "discontinuities and disruptions" (Stentoft & Valero, 2009, p. 58). Through the discursive opportunities of their autobiographical writing and reflection, PMTs negotiate ideas of both what it means to know and do mathematics, as well as what it means to know and do mathematics teaching. As these personal epistemologies emerge, likely the PMTs will also consider the development of knowledge by their future students, potentially positioning them as authors of mathematics, creators of knowledge (Povey & Burton, 1999).

Methods

This exploratory, qualitative study drew upon autobiographical narratives of PMTs to consider their negotiation of sociopolitical mathematics teacher identities. Although the MTE-Partnership Equity Working Group has not yet been formalized into a Research Action Cluster (RAC), this exploratory study aligns with the premise of the MTE-Partnership network as a design community drawing on improvement science (Bryk, Gomez, & Grunow, 2010), and will likely inform future PDSA cycles suggested by the Working Group's soon-to-come driver diagram. In this study, we examined the challenges put forth by MTE-Partnership Principle 6-C, Sense of Justice, and AMTE Standard C.4, Social Contexts of Mathematics Teaching and Learning.

To conduct this study, we pursued a method of narrative inquiry in which we systematically gathered, analyzed, then selected elements of PMTs' stories as told by them. Stories, in this case autobiographies, are reconstructions of a person's experiences, remembered in a particular context / moment in time, and for a particular purpose. This has a bearing on which stories are told, and how they are told. They are not stories of life as lived, but a re-presentation of one's life as told by the person. As a result, subjective meanings and sense of self and identity are negotiated as the stories unfold. Narrative inquirers strive to attend to the ways in which a story is constructed, for whom and why, as well as the cultural discourses that it draws upon.

Autobiographical and auto-ethnographic work (e.g. Dunn, 2005) has been used to support PMTs in becoming aware of and reflecting on their own mathematics experiences to think critically about their attitudes and beliefs about mathematics teaching and learning. Mathematics teacher educators make use of autobiographical writing in mathematics methods courses to press PMTs to examine social, cultural, and ideological assumptions as they learn to teach for diversity through mathematics (e.g. Aguirre et al., 2013; de Freitas, 2008). In this study, we drew upon the autobiographical writing produced in a mathematics methods course that explicitly engaged PMTs in questions from a CME tradition of teaching for equity and social justice, to better understand how PMTs engaged in this work envision and articulate what it might mean to be or become a critically conscious mathematics teacher. That is, we sought to learn what we could about their sociopolitical mathematics teacher identities. Analytically, the autobiographical reflection work of PMTs provides a lens into the ways they negotiate their own ever-evolving identities as critically conscious educators.

The 12 participants in the study were enrolled in Lawler's fall 2016 course "Teaching Mathematics in the Middle Grades." Drawing from a critical orientation to issues of equity and social justice, among Lawler's course goals were to challenge and broaden PMTs ideas about mathematics education. To address assumptions about teaching mathematics PMTs bring to the methods class, Lawler utilized a multistage mathematics autobiography (mathography) to draw out PMTs' awareness of their own identity as a person who does (and learns and creates) mathematics and as a person who teaches mathematics. This explicit attention to the sociopolitical mathematics teacher identities of the PMTs also may encourage them in turn to become more attuned to their own future students' mathematical identities.

Gargroetzi and Lawler separately examined the data collected, relying on emergent coding to identify themes across the writings of all 12 students. As certain themes became particularly salient such as the linkages between how PMTs discuss the mathematical and sociopolitical identities of themselves or their students, Gargroetzi "zoomed in" to analyze the micro-interactional positioning accomplished within the writing itself that told these stories, focusing on examples from the work of a few students. Similarly, Lawler analyzed the text collectively to capture samples that seemed to demonstrate various epistemological perspectives, such as author/ity, and positioned the PMTs' future students as mathematical authors—or not.

Findings

Gargroetzi's analysis, from the Positional approach, identified a variety of stances (i.e. positions) that PMTs were taking toward themselves and their role in the mathematics classroom. Some of the stances could be organized into Gutiérrez' (2002) dominant and critical approaches to equity: access/achievement and identity/power. Others didn't fit so neatly into those categories, and thus were labeled as Crossover—referring to the manner which the first two stances seemed to be intertwined. Samples of these stances can be found in Table 1.

Text from the PMTs writing serves to illustrate these stances. A first example demonstrates a stance centered on access, access to mathematical knowledge as disciplinary, as well as access to love of math, both as bounded items held by the teacher and available for distribution at the teacher's discretion: "teachers … gave me my love for math. They created a fun environment that was challenging yet rewarding. These are the people that make me want to pass my knowledge onto other students and share my love of math" (H, M). This example is structurally about providing access. In this second example, emphasis lies on a different teacher role, one in which the teacher serves as a connector between mathematics and other elements of student's identity (and life):

> My main goal for myself as a teacher is to create lessons that apply to my students' day to day lives. I do not see the point in teaching mathematics if you do not also teach how it is applicable

> to them personally. In order to do this I have learned that I first must give opportunities for my students to identify as mathematicians. As a result, my main goal for my students is to help them see the value in their schooling as well as helping them see their value as students. (J1, L)

Table 1

Stances (i.e. positions) PMTs took toward themselves and their role in the classroom

Stance Type	Example
Access & Achievement	Teacher as gate-opener to beauty and joy of mathematics
	Teacher as protector from potential trauma
Power & Identity	Teacher as encourager of student confidence and independence
	Teacher as facilitator of connections between the classroom and the student's lived world
	Teacher as learner, students as people to learn from
Cross-over	Teacher as change-agent for a conceptual, exploratory mathematics education that will include all students

These orientations to the dominant and critical axes in Gutiérrez' (2012) framework seemed to intertwine is in this crossover stance: "I want to create student-led lessons, lessons that involve groupwork and give my students the opportunity to participate in their learning rather than simply being recipients of my instruction" (N, L). This PMT positions students a capable and desiring of participating in their own learning even as she positions herself as the one who holds power over the access to that experience.

These three stances as articulated by PMTs at different moments reveal varying orientations to the relations of power between teacher and student. While the dominant orientation positions the teacher as the gate-keeper to knowledge or experience, even potentially liberatory experience, critical stances position the teacher as a participant and collaborator in the student's always-already engaged pursuit of meaning-making, as well as positioning the student as an other from whom meaningful wisdom can be gleaned.

Lawler analyzed the data from a post-epistemological standpoint with an orientation toward what may constitute evidence of a personal epistemology, specifically the author/ity orientation (Belenky et al., 1986; Povey & Burton, 1999). That is to say, Lawler did not attempt to create models of any PMT's personal epistemology, rather focused on the process of identifying what may constitute evidence. Three personal epistemological perspectives were apparent: silenced, external authority, and author/ity. The first of the perspectives, silenced, is characterized by the person experiencing themselves as mindless and voiceless, subject to the whims of an authority for knowing external to themselves. The following passage from one PMT's mathography suggests this perspective, "I remember very clearly the sweaty palms, nervous itch, feeling of suffocating, and the anxiousness whenever I had to take a math test, or when my teacher asked me a question in front of the entire class" (S, M). The silenced PMT does not see themself as developing, acting, learning, planning, or choosing.

A second perspective is of external authority, in which authority for knowing is experienced as external to the self and belonging to the experts. "Meaning is taken as given and knowledge is assumed to be fixed and absolute rather than contextual and changeable" (Povey & Burton, 1999, p. 234). Several of the examples provided by the PMTs are as follows:

- "helping students to understand" (J1, M)
- "Math has always made me feel empowered, even when I struggled with it the most" (N, M)

- "I hope to teach them how to be persistent in discovering mathematics, and I hope to teach them how to research and discover concepts on their own." (J1, L)

The third perspective observed in PMTs personal epistemologies was author/ity. When one views oneself as an author, they use their (mathematical) voice "to enquire, interrogate and reflect upon what is being learned and how" (Povey & Burton, 1999, p. 232). "External sources are consulted and respected but they are also evaluated critically by the knowledge makers, those making meaning of mathematics in the classroom, with whom author/ity rests" (p. 236).

- "I like knowing that when I finished a problem I know I have the correct answer." (SI, M)
- "I feel that if I would have learned to explain myself I wouldn't struggle as much as I do now in my university level classes. Many times I am unable to find the words to show that I know what I am doing. I have to take the time and really examine the process I used to come to my conclusions." (NR, M)
- "I am excited to learn different perspectives that my students will have that differ from my own." (J1, L)

These examples of PMT identity that aligns with a personal epistemology oriented toward author/ity suggest a future teacher who will support a renegotiation of the relations of dominance embedded within current conceptions of the nature of mathematical knowledge. This personal epistemological perspective values meaning making, and recognizes the vitality and importance of the process of mathematical knowledge construction within a community of learners, relocating the privileging of mathematics from outside experts to child authors, generating a liberatory classroom practice (Povey & Burton, 1999).

Conclusions

This investigation served two purposes, primarily to understand better PMTs sociopolitical mathematics teacher identities. Second, to inform future work by the MTE-Partnership Equity Working Group as they consider strategies to address PMTs tacit ideological assumptions and provide a structure for the mathematics teacher educator to promote sociopolitical goals. This work suggests the potential for multistage mathematical autobiographies built around activities in the mathematics methods course to promote sociopolitical mathematics teacher identities.

Further, and more broadly, the introduction of the idea of a sociopolitical mathematics teacher identity may contribute to the present work on identity occurring in the field. We consider a sociopolitical mathematics teacher identity entails, at least in part, attending to the emerging and performed mathematical identities of one's own students—whether taken up as one's own, or, sustained and performed over time. Giving attention to the emerging sociopolitical mathematical identities of prospective teachers is one element of achieving the more complex, justice-oriented goals in the preparation of mathematics teachers.

References

Aguirre, J., Mayfield-Ingram, K., & Martin, D.B. (2013). *The impact of identity in K-8 mathematics: Rethinking equity-based practices*. Reston, VA. NCTM.

Association of Mathematics Teacher Educators (AMTE). (2016). *Standards for preparing teachers of mathematics.* Available online at https://amte.net/standards

Belenky, M.F., Clinchy, B.M., Goldberger, N.R., & Tarule, J.M. (1986). *Women's ways of knowing: The development of self, voice, and mind.* New York: Basic Books.

Bryk A. S., Gomez L. M., & Grunow A. (2010). *Getting ideas into action: Building networked improvement communities in education*. Stanford, CA: Carnegie Foundation for the Advancement of Teaching. Retrieved from https://www.carnegiefoundation.org/wp-content/uploads/2014/09/bryk-gomez_building-nics-education.pdf

Davies, B., & Harre, R. O. M. (1990). Positioning: The discursive production of selves. *Journal for the Theory of Social Behaviour, 20*(1), 43–46.

de Freitas, E. (2008). Troubling teacher identity: Preparing mathematics teachers to teach for diversity. *Teaching Education, 19*(1), 43–55.

Dunn, T. K. (2005). Engaging prospective teachers in critical reflection. In A. J. Rodriguez & R. S. Kitchen (Eds.), *Preparing mathematics and science teachers for diverse classrooms* (Vol. 53, pp. 143–158). Mahwah, NJ: Lawrence Erlbaum.

Frankenstein, M. (1983). Critical mathematics education: An application of Paulo Freire's epistemology. *Journal of Education, 165*(4), 315–339.

Gargroetzi, E. C., & Lawler, B. R. (2017). Sociopolitical mathematics teacher identity: Mathography as window. In A. Chronaki (Ed.). *Proceedings of the Ninth International Mathematics Education and Society Conference* (pp. 222-226). Volos, Greece: University of Thessaly Press.

Gee, J. P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education, 25*, pp. 99–125.

Gutiérrez, R. (2002). Enabling the practice of mathematics teachers in context: Towards a new equity research agenda. *Mathematical Thinking and Learning, 4*(2 & 3), 145–187.

Gutiérrez, R. (2013). The sociopolitical turn in mathematics education. *Journal of Research in Mathematics Education, 44*(1), 37–68. [originally published online in 2010]

Herbel-Eisenmann, B. A., Wagner, D., Johnson, K. R., Suh, H., & Figueras, H. (2015). Positioning in mathematics education: revelations on an imported theory. *Educational Studies in Mathematics, 89*, 185–204.

Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (1998). *Agency and identity in cultural worlds.* Cambridge MA: Harvard University Press.

Langer-Osuna, J. M., & Esmonde, I. (2016). Insights and advances on research on identity in mathematics education. In J. Cai (Ed.), *First compendium for research in mathematics education* (pp. 1–36). Reston, VA: NCTM.

Lawler, B. R. (2012). The fabrication of knowledge in mathematics education: A postmodern ethic toward social justice. In T. Cotton (Ed.), *Towards an education for social justice: Ethics applied to education* (pp. 93–108). London, England: Peter Lang.

Mellin-Olsen, S. (1987). *The politics of mathematics education.* Norwell, MA: Kluwer Academic.

Mathematics Teacher Education Partnership (MTE-Partnership). (2014). *Guiding principles for secondary mathematics teacher preparation programs.* Available online at www.aplu.org/projects-and-initiatives/stem-education/SMTI_Library/mte-partnership-guiding-principles-for-secondary-mathematics-teacher-preparation-programs/File

Povey, H., & Burton, L. (1999) Learners as authors in the mathematics classroom. In L. Burton (Ed.) *Learning mathematics: From hierarchies to networks* (pp. 232–245). London: Routledge.

Sfard, A., & Prusak, A. (2005). Telling identities: In search of an analytic tool for investigating learning as a culturally shaped activity. *Educational Researcher, 34*(4), pp. 14–22.

Stentoft, D., & Valero, P. (2009). Identities-in-action: Exploring the fragility of discourse and identity in learning mathematics. *Nordic Studies in Mathematics Education, 14*(3), 55–77.

von Glasersfeld, E. (1995). *Radical constructivism: A way of knowing and learning*. London: Falmer.

Wortham, S. (2006). *Learning identity: The joint emergence of social identification and academic learning*. Cambridge University Press.

Support Systems of Early Career Secondary Mathematics Teachers and Their Effects on Teacher Retention (STRIDES)

Lisa Amick, University of Kentucky, Lisa.Amick@uky.edu
James Martinez, University of Tennessee at Knoxville, Jamartinez64@gmail.com
Megan Taylor, Trellis Education, Megan@TrellisEducation.org

Abstract

The goals of the Mathematics Teacher Education Partnership (MTE-Partnership) include building national dialogue around the preparation of mathematics teachers and promoting partnerships and model programs in the teacher development process with an emphasis on instructional chance. The goals of the STRIDES (Secondary Teacher Retention in Diverse Instructional Settings) Research Action Cluster (RAC) are aligned to these overarching goals by seeking to support teacher retention efforts. More specifically, the goal is for at least 85 percent of the early career secondary mathematics teachers in MTE-Partnership partner school districts to begin a third year of employment as a mathematics educator.

Our data was collected from a series of national surveys of mathematics teachers in their first three years of teaching. The initial pilot survey was created by a team of researchers and educators from 13 universities and four K-12 school districts and involved a yearlong study of 41 teachers. The final survey, devised from data gleaned from the pilot, was administered in December of 2016, with 141 respondents. The main objective of the final survey was to gather information about how these teachers perceive they were being supported and inform initiatives aimed at improving teacher retention rates. The survey focuses on what types of professional activities and communities in which teachers are participating, their perceptions of these activities, and how practice is influenced. Additional questions focused on administrative and university support, job satisfaction, and anticipated longevity in the field.

Keywords: professional development, teacher education, teacher beliefs/attitudes

Theoretical Framework

Research has defined key components of a more cohesive and effective system of mathematics teacher preparation and development that facilitates teacher growth and retention. Our theory of action focuses on one of these components: ensuring early career mathematics teachers have high-quality, content-specific professional support. We followed the conceptual framework laid out by Bryk, et al. (2015) and used a Plan-Do-Study-Act (PDSA) cycle throughout our research project.

Methodology

To support the efforts on teacher retention, researchers in the STRIDES RAC developed a survey to administer to early career secondary mathematics teachers to learn about their professional support. The researchers developed the "Reflection on Professional Activities" survey in iterative cycles of survey design, implementation, and data analysis, including a yearlong pilot with 41 early career mathematics teachers. The final survey is an electronic, 25-item survey asking secondary mathematics teachers in their first, second, or third year of teaching – early career mathematics teachers – to reflect on the degree to which participating in professional learning activities and communities increased their enthusiasm for teaching mathematics and influenced their ability to facilitate student learning. The full survey was distributed nationwide by email in the late fall 2016 and as of December 2016, 141 early career mathematics teachers completed the survey. The data from this survey was analyzed in the spring 2017, interventions were devised in the summer 2017, and their implementation is scheduled for the 2017-2018 school year.

Participants

The participants of this study were solicited first through the STRIDES RAC and secondly through the MTE-Partnership team. MTE-Partnership members reached out to early career secondary mathematics teachers asking if they wanted to participate in a survey, and then administering that survey through a Google form sent via email.

Twelve percent of the respondents designated themselves as pre-service teachers, 26 percent in their first year, 26 percent in their second year, and 36 percent in their third year of teaching. An overwhelming number (94 percent) of these teachers were serving in public secondary schools in rural (13 percent), suburban (32 percent), and urban (23 percent) settings, and teaching in a full range of classes from sixth-grade general math through calculus. The schools they were serving were characterized by their teachers as low-SES (26 percent) and high-SES (9 percent). Most (72 percent) of the pre-service and early career teachers surveyed stated that between 5 percent and 20 percent of the students they were teaching had Individual Educational Plans (IEPs), 59 percent stated that between 5 percent and 20 percent of their students were designated as English Language Learners (ELLs), and 55 percent of them reported that between 40 percent to 100 percent of their students qualified for free and/or reduced lunch.

Initial Quantitative Data

Initial data analysis shows that most of the pre-service or early career teachers surveyed (81 percent) "certainly" or "probably" would become a teacher "if (they) could go back and start college again" and nearly half (46 percent) of them would remain in teaching "as long as (they) were able," The majority of teachers (53 percent) say that they spent between one and two hours a week involved in professional learning activities and another 18 percent say they spend three to five hours a week. Teachers reported spending a large chunk of their weekly time planning with colleagues (56 percent spend 1-2 hours, another 27 percent say 3-5 hours) and another large amount of time planning alone (35 percent spend 6-10 hours, another 30 percent say 3-5 hours). Sixty-three percent of respondents report spending more than 20 hours a week teaching. Regarding professional learning activities that "increase their enthusiasm for teaching mathematics," working/communicating with a mentor or coach rated the highest among all choices (83 percent responding that it was either moderately or very influential). In terms of support from administrators in a variety of areas (curriculum, classroom management, course assignments, assessment, instruction, collaboration and affirmation), the respondents relied to a much larger degree on those who were on-site (principals and assistant principals) rather than university professors and district office personnel.

Initial Qualitative Data

When teachers were asked what they wish were different about their job, the words that were mentioned most frequently were support, non-teaching duties, class size, collaboration, student behavior, and pay. Participants also reported that the most-used online forums for professional use were blogs and Twitter. When asked to describe a professional learning opportunity the teachers participated in that had a positive effect on their ability to facilitate student learning, teachers described a wide variety of activities, some of which were embedded in formal or informal professional learning communities. For example, one teacher described a community of first-year teachers the school district created, and many teachers described their departments as versions of PLCs that supported their teaching practice. Few teachers described formal professional learning communities created or facilitated by their university teacher preparation program or school district, but many teachers reported access to mentors or coaches. One teacher reported:

> I am currently participating in an Algebra 1 blended learning pilot being conducted by the state department. I meet bi-weekly with a coach online to discuss teaching practices and strategies. Our time together is invaluable as he provided practical suggestions and recommendations for improving my teaching.

The "positive effect" of the support teachers described tended to be either related to a change in a planning or teaching strategy, move or structure (e.g., [I learned] "the regal look - a look you give your students when you want them to be quiet") or to feeling generally "prepared" to teach. Another teacher wrote:

> I participated in an activity known as Math Talk during the Integrated Mathematics Summer Institute held at Belmont University. During the activity, students are presented with a mental math problem. They are not allowed to use calculators or writing utensils, only their brains, to solve it. The students indicate with a thumbs-up if they are ready with a solution. Once the class is ready, the teacher asks for any and all solutions. The teacher does not discuss the quality of the solutions yet, just asks for all possible answers. Once all possible answers are listed, the teacher will begin asking the students to talk about how they arrived at a particular solution. The teacher also asks other students who arrived at the same answer to compare their thinking strategies with the other students who got the same answer. This activity was influential for me because it allowed me to see the endless ways students can mentally see and think about mathematics. It also encouraged me to help students compare their thinking with others, in order to grow their understanding of a topic. Most importantly, it has helped me help my students make connections between the way they currently see mathematics and all of the new ways they can see mathematics. Some of the information presented during my Residency classes has been influential. We did some community building activities and they made me realize how important a strong community is for the classroom. We talked at a conference about working on growth mindsets. It was beneficial to know how to word ideas to help facilitate and modify mindsets.

Lastly, participants were asked to describe how a professional learning activity increased their enthusiasm for teaching mathematics. Most of the responses fell into two categories. The first category is teachers who are inspired and rejuvenated by working with someone who has an infectious, enthusiastic attitude about teaching. The second category of responses was enthusiasm gained by trying out new ideas in the classroom and seeing their students succeed with them. Teachers learned of new activities via conferences, blogs, meetings with colleagues and various other ways and described how invigorating it was to customize these ideas to fit the needs of their students, try them on using their own teaching style, and see their students succeed.

Next Steps

The main takeaway from our study is that when teachers feel supported, they have the desire to want to stay in the field of education for longer periods of time, and that meaningful support can come in a variety of forms. Our next steps include working with teachers in the MTE-Partnership to identify support systems that are working and replicate those in settings where teachers are not supported. At the annual MTE-Partnership conference in June of 2017, two initial interventions were developed. These targeted interventions will be implemented during the 2017-2018 school year with a goal to expand meaningful support for early career mathematics teachers and to increase teacher retention at large, serving as proof of principle for more wide-scale efforts. The first intervention will include replication of the best parts of mentor systems within more of our partnership schools. The second intervention includes working with administrators so that they are knowledgeable about working specifically with new teachers and supporting them during these critical years. Lastly, sharing this research will inform the larger audience as well as serve as an example of school-university partnerships that function cooperatively to solve the issues of retention of secondary mathematics teachers.

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*. Cambridge, MA: Harvard Education Press.

Using Co-Planning and Co-Teaching during Clinical Experiences and as Early Career In-service Teachers

Patti Brosnan, The Ohio State University, brosnan.1@osu.edu
Ruthmae Sears, University of South Florida, ruthmaesears@usf.edu

Abstract

Considering that teacher attrition is higher in schools with high-poverty rates, exploring ways to improve clinical experiences to better prepare teachers to work in these environments is important to address needs of diverse learners. In this study, we examine how co-planning and co-teaching (CPCT) could be used as a collaborative process, to place a focus on learning, and to develop pre-service teachers' and in-service teachers' skills to work in diverse environments. We garnered data from two secondary mathematics teachers over a five-year period, starting prior to the Mathematics Teacher Education Partnership. An analysis of data collected from narratives, surveys, and evaluation reports indicated that CPCT was indeed influential in the development of the two teachers' instructional practices and their overall preparedness to work in high-need schools.

Keywords: Co-Planning and Co-Teaching, pre-service teachers, in-service teachers, clinical experience, induction

Introduction

Since 2013, the Association of Public Land-Grants Universities (APLU) Mathematics Teacher Education Partnership (MTE-Partnership) clinical experiences research action cluster (RAC) had a network improvement community (NIC) that focused on using co-planning and co-teaching (CPCT) (Brosnan & Sears, 2016; Bacharach, Heck & Dahlberg, 2010; Sears et al., 2017). Co-teaching is a pedagogical approach that promotes collaboration and communication between instructional pairs who share their space to deliver instruction, organize classroom environments, and administer assessment (Bacharach, Heck & Dahlberg, 2010; Sears et al., 2017). According to Sears et al., (2017), "Co-teaching is a paradigm shift from the traditional clinical experience because the sharing of responsibility is promoted and emphasized between the mentor and preservice teacher" (p. 267).

Our NIC found that using CPCT during clinical experiences increased opportunities for pre-service teachers and their mentor teachers to address diverse needs of students and promoted a culture of mutual respect (Sears et al., 2017). This paper extends the narrative of the implications of using CPCT by considering the impact of teachers using CPCT with a focus on learning, during their clinical experiences and induction years. Thus, this paper will trace two secondary mathematics teachers from pre-service to in-service, and it will consider the extent they used CPCT to promote learning and how using CPCT has impacted their teaching in urban settings.

Problem and Purpose

Considering that there is a need to recruit and retain effective teachers, teacher preparation programs are challenged to meet the national demand of preparing effective teachers (Carroll & Foster, 2010; Darling-Hammond, 2010). The extent to which teachers are deemed effective and are prepared to teach a diverse group of students may be influenced by the quality of teacher education preparation programs (Darling-Hammond, 2000). Thus, teacher preparation programs are challenged to develop pre-service teachers to be effective teachers in a diverse society in which they will eventually work (Darling- Hammond, 2000; Koehler & Mishra, 2009).

Furthermore, being cognizant that the attrition rates of teachers are higher in schools with high poverty rates, which is typically common in urban environments, a greater attention ought to be placed on preparing teachers to be effective in an urban context (Darling-Hammond, 2010). Thus, it is recommended that pre-service teachers be provided opportunities to learn about teaching in diverse contexts, be welcomed into the professional community, and be encouraged to promote professional standards of the discipline (National Council of Teachers of Mathematics [NCTM], 2014; Sowder, 2007). Thus, the purpose of this study is to describe how using CPCT, with a focus on learning, can be used to promote the development of teachers who work in urban settings during their clinical experiences and induction years.

Conceptual Framework

To frame the nature of our inquiry, we used a conceptual framework entitled "An Apprenticeship Model for Learning." There are three components of our conceptual framework including: a) an apprenticeship approach, b) a collaborative process of CPCT, and c) a focus on learning mathematics. First, the apprenticeship approach is a process of developing pre-service and novice in-service teachers under the guidance of an experienced urban educator (Downey, Dalidowicz, & Mason, 2015). During the apprenticeship, which focuses on cultivating student learning, mentor teachers introduce pre-service teachers and/or novice teachers as co-teachers the first day of class, to position the individual as an equal in the eyes of the students. The mentor teachers frequently conduct "teach alouds" to make instructional decisions public to their apprentice. The second component focuses on cultivating collaboration using CPCT. Thus, during the collaborative process the instructional pair reflects on the following questions: What do you want students to learn? How will you know if they learned? And in what tasks will students engage to get the learning to happen? By working as a team, the collaboration positively affects the practice of both the mentor and their apprentice over time (Brosnan & Sears, 2016). Finally, the third component of the framework focuses on learning using cognitively guided instruction (CGI), which is a philosophical and pedagogical stance regarding the teaching and learning of mathematics. Using the CGI protocol (adapted to secondary levels) to focus on student thinking by listening to their explanations of solution strategies of rich mathematical tasks has proven to assist teachers in learning how to navigate instruction based on what they learned from student thinking (Carpenter, Fennema, Peterson, Chiang, & Loef, 1989). Thus, as we seek to examine the implication of CPCT, considering the components of the framework, and their points of intersection provided greater insights of means to develop teachers to work in urban settings.

Research Question

For this study, our overarching research question is: To what extent does CPCT contribute to teachers', who work in urban settings, professional growth during clinical experiences and induction years?

Methods

Our connections to the MTE-Partnership are evidenced by our work within the essential characteristics of improvement strategies (Martin & Gobstein, 2015) to: a) focus on a common problem within mathematics teacher education regarding clinical experiences and induction years, b) develop a deep understanding of the systems that provide clinical experiences and professional development and support to novice teachers, c) use a cyclic process of developing, teaching, and refining our approach, and d) working within a NIC to carefully study how our improvement efforts can vary across participating contexts.

Therefore, although our work began before the MTE-Partnership was conceptualized, being a part of the NIC provided greater insights of means to support teachers during their clinical experiences and inductions years. To nurture relationships formed by CPCT, instructional pairs were encouraged to attend professional development together, and provide feedback to the program on a regular basis. An intervention was implemented if there were challenges identified. Teachers also acknowledged that they used at least one free period a week to engage in CPCT with their instructional pair, whenever possible. Thus, we have used PDSA cycles to plan, do, study, and act in developing and refining our collective approaches to improve clinical experiences that aim to produce higher numbers of effective secondary mathematics teachers as evidenced by improved student learning. We further sought to retain effective teachers of mathematics in the classroom setting.

Data Collection and Analysis

To enhance our learnings and to deepen our understanding of the potential implications of using CPCT to improve the development of mathematics pre-service and in-service teachers who work in urban settings, we collected data over a five-year period beginning prior to the creation of the MTE-Partnership. Particularly, we employed a qualitative research narrative to report one institution's attempt to document the professional development of pre-service teachers and in-service teachers early in their careers. Data were garnered from two mathematics teachers (one in an urban middle school and the other in an urban high school). The urban schools in which the teachers worked had a high population of free and reduced lunch, and a high teacher turnover rate. During the 2013-2014 school year, of the 53,327 students enrolled in schools within this district, 73 percent were students of color, 79 percent were students who were socio-economically disadvantaged, and 12 percent were students with limited English proficiency. In addition, the student mobility rate was 17 percent. Data were collected via narratives, surveys, and evaluators' reports. The narratives captured written reflections by the participants describing how the conceptual framework, described above, helped or hindered their progress. The surveys included questions to elicit additional detail of the two participants' perspectives about their development as mathematics teachers. The evaluators' reports were from district personnel who were charged with providing feedback on instructional practices for pre-service and novice teachers as well as from external evaluators on the funded project.

We initially analyzed the data from the lens of the conceptual framework. Subsequently, we documented other emergent themes. To document the results, we considered their perspectives about CPCT across the spectrum from their clinical experiences to their induction years, and subsequently as mentors of pre-service teachers.

Results

We found that these two participants viewed CPCT to be helpful in their professional development as mathematics educators. The middle school teacher reported that during his clinical experiences his mentor did not engage him in CPCT, so he felt that what he learned was rather limited. However, when he engaged in CPCT during his induction years, he noticed an improvement in his craft of teaching. The high school teacher reported that he used CPCT as a pre-service teacher and learned much as a result of it. Hence, the high school teacher became frustrated that he was not able to continue this collaboration when he took a position as a new faculty. Thus, he expressed enthusiasm when, after three years of teaching, he was afforded an opportunity to use CPCT with a pre-service teacher that he mentored. In the subsequent paragraphs, we will describe the participants' perspectives about co-teaching as pre-service teachers, early career teachers and subsequently mentors, while taking into account the components of the conceptual framework.

Pre-service Interns and Evaluator

Using CPCT during clinical experiences was viewed as a positive approach to prepare one novice teacher, compared to traditional methods. For instance, the middle school teacher said,

> When I went through the traditional method as an intern, I didn't do much when I started out. My main responsibility was to observe. I wasn't doing much, therefore, I didn't feel as if a learned much. (Middle School Intern – Narrative. June, 2015)

The lack of guidance offered during a traditional clinical experience did little to help the pre-service teacher enhance his instructional craft. In contrast, the high school teacher, who used CPCT during his clinical experiences, acknowledged his readiness to teach. He noted,

> When I thought of teaching my view was having my own classroom where I would essentially plan things on my own with no assistance or collaboration with other teachers. I also never expected that I would co-teach a class with one of my colleagues. This positive experience as a graduate student working with a mentor teacher helped me feel prepared to begin to teach. (High School Intern – Survey. October, 2016)

Additionally, the district evaluator reported that teachers who had clinical experiences that used CPCT appeared more prepared to teach than their peers who were prepared using alternative approaches. The district evaluator noted,

> Interns who are in the Project come to school three steps ahead of those not in the Project. They seem to have a sense of working with urban children; they do a nice job of setting expectations, and framing their consequences in a positive way. (District Evaluator; Interview 2. March, 2012)

Thus, CPCT appeared to have a positive impact on pre-service teachers' clinical experiences.

Early Career Teachers

The use of CPCT was found rewarding to support the development of participants during induction years. The middle school teacher noted,

> Co-planning and co-teaching, if done correctly...in all its glory, is not only effective for pre-service teachers, but for all teachers. Not only should the model be extended to first year, second year, and third year teachers, but for all teachers. (Early Career Middle School Teacher – Narrative. June, 2015)

The high school teacher who implemented CPCT with a pre-service teacher echoed similar sentiments. Initially, this opportunity was not afforded to him and he felt isolated. Hence, when he was able to use CPCT he welcomed the opportunity since he believed it more readily facilitated learning. The high school teacher noted,

> My first two years of teaching, I found myself isolated from other math teachers. I had very little opportunity to co-plan or co-teach within my school, and wondered if this was how it would be when teaching in high school, or if I would be presented with more opportunities in the future. (Early Career High School Teacher – Narrative. June, 2015)

Thus, these teachers perceived using CPCT during teachers' induction years as beneficial.

Role Reversal, "Now, I'm the Mentor!"

When the early career teachers became mentors, they continued to echo the sentiment that CPCT can be used to enhance student learning in urban contexts. For instance, the middle school teacher noted,

> CPCT was effective for me, the mentor, because I had another teacher in my classroom. I now had TWICE the number of people available to clarify instructions, or answer questions, or ask questions. This meant less idle time, more time on task, and more learning.
>
> Through…collaboration, I also became a better teacher. I discovered better questions, new lessons, and other means of assessment. Finally, I was always in control of my class. With the amount of responsibility a teacher has over their students' learning, I liked this component of the CPCT model as well. (Early Career Middle School Teacher– Narrative. June, 2015)

Similarly, the high school teacher indicated that the intersection of the conceptual framework provides opportunities to collaborate and cultivate critical thinking. He noted,

> I learned how to talk to my intern and co-workers in ways to encourage thinking instead of just giving suggestions or answers. Using Cognitive Coaching^SM within my professional environment created a

> stronger sense of collaboration, between everyone involved, because it really allowed for original thinking. (Early Career High School Teacher– Narrative. June, 2015)

He continued,

> I found that the level of learning was much higher among the students during the time in which my intern and I collaborated on lessons. We took time to plan out lessons together and create ideas and explorations that allowed students to have more in-depth learning and build their own conclusions about the concepts they were learning. (Early Career High School Teacher– Narrative. June, 2015)

The mathematics teacher participants who used CPCT during mentorship reported that this process helped improve student learning and fostered collaboration within the team.

Furthermore, data from the district representatives and the program evaluation by external reviewers also confirmed our observations. For instance, the district representative noted that they were able to recognize program graduates because "they appear to be more effective than their peers who obtained their teacher certification via alternative pathways." Likewise, the external evaluators found that pre-service teachers and in-service teachers in the program were generally pleased with the support and training offered by the program. More specifically, evaluators reported that program graduates "… benefitted from the two main enhancements …—the yearlong Urban Teaching Seminar (UTS) with its focus on culturally relevant pedagogy, and placements with mentors for sustained mentoring relationships built around co-planning and co-teaching. The UTS evolved considerably over the course of the project, particularly from Year 2 to Year 4; evaluation findings suggest that the seminar began to strike a better balance between theory and practice. As a result, interns came away with an increased ability to understand and effectively work within urban classrooms and communities." The evaluators continued, "These improvements were likely due to the mentoring becoming more focused on actively assessing their students' learning, and were more likely to be engaged as problem-solvers in the co-planning/co-teaching process."

Conclusion

In closing, we found that using CPCT in an apprenticeship model can facilitate collaboration, and learning outcomes for project participants. Our mentors and interns came away from these experiences viewing teaching as a collaborative process. Both teachers felt that planning for learning increased student-learning opportunities, which influenced their perspectives to use CPCT as much as feasibly possible. As we consider reflecting on means to retain mathematics teachers in the profession, our future studies should explore scaling up our efforts and collecting both quantitative and qualitative data on the impact of CPCT over a spectrum of years of professional experiences as well as in a multitude of diverse learning contexts. Although our study was set in an urban environment, the findings can be valuable regardless of context if the goal is to promote student learning, and retain teachers during their induction years, considered the teachers' agency was enhanced, and their willingness to return to the classroom in subsequent years was increased.

References

Bacharach, N., Heck, T. W., & Dahlberg, K. (2010). Changing the face of student teaching through coteaching. *Action in Teacher Education*, *32*(1), 3-14.

Brosnan, P., & Sears, R. (2016). *Using improvement science to increase mathematical learning through co-planning and co-teaching*. In B. R. Lawler, R. N. Ronau, & M. J. Mohr-Schroeder (Eds.). (2016). Proceedings of the fifth annual Mathematics Teacher Education Partnership conference, Atlanta (pp. 143-149). Washington, DC: Association of Public and Land-grant Universities.

Carpenter, T. P., Fennema, E., Peterson, P. L., Chiang, C. -P., & Loef, M. (1989). Using knowledge of children's mathematics thinking in classroom teaching: An experimental study. In T. P. Carpenter, J. A. Dossey & J. L. Koehler (Eds.), *Classics in Mathematics Education Research* (pp. 135-151). Reston, VA: National Council of Teachers of Education.

Carroll, T. G., & Foster, E. (2010). Who will teach? Experience matters. *Washington, DC: National Commission on Teaching and America's Future.*

Darling-Hammond, L. (2010). Recruiting and retaining teachers: Turning around the race to the bottom in high-need schools. *Journal of Curriculum and Instruction*, *4*(1), 16-32.

Darling-Hammond, L. (2000). How teacher education matters. *Journal of Teacher Education*, *51*(3), 166-173.

Downey, G., Dalidowicz, M., & Mason, P. (2015). Apprenticeship as method: embodied learning in ethnographic practice. Qualitative Research, 15(2), 183-200.

Koehler, M. J., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education*, *9*(1), 60-70.

Martin, W.G. & Gobstein, H. (2015). Generating a networked improvement community to improve secondary mathematics teacher preparation network leadership, organization, and operation. *Journal of Teacher Education, 66* (5), 482-493.

National Council of Teachers of Mathematics (NCTM). (2014). *Principles to action: Ensuring mathematical success for all*. Reston, VA: Author.

Sears, R., Brosnan, P., Gainsburg, J., Oloff-Lewis, J., Stone, J., Spencer, C., Riggs, L., Biagetti, S., Cayton, C., Grady, M., Junor Clarke, P., & Andreason, J. (2017). Using improvement science to transform internship experiences with co-planning and co-teaching strategies. In West, L., *NCTM. (2017). APME 2017*: *Reflective and Collaborative Processes to Improve Mathematics Teaching*. NCTM. Reston, VA.

Sowder, J. T. (2007). The mathematics education and development of teachers. In F. Lester, *2nd Handbook of Research on Mathematics Teaching and learning: A project of the National Council of Teachers of Mathematics*, Volume *1*, 157 -224. Reston, VA: NCTM.

Prospective Teachers Running Active Learning Breakout Sections: What We've Learned in Four Semesters

Janet Bowers, San Diego State University, Jbowers@mail.sdsu.edu

Robert Hanna, San Diego State University, bobhannatutor@gmail.com

Emilie Meredith, San Diego State University, EMeredith@sdsu.edu

Abstract

This chapter reports on a program in which undergraduate STEM majors teach active learning breakout sections for a precalculus course. Our goal is to determine what benefits the students experienced from teaching and whether these experiences influenced their decision to become teachers. The findings suggest that (1) several STEM majors who were not initially planning to teach stated that they are now considering teaching as a career, and (2) program participants who were prospective teachers developed their identities as mathematics teachers more strongly than their peers who did not teach breakout sections (even though both groups took the same prep courses). This report intersects the foci of three RACs within MTE-Partnership: Developing Effective Clinical Experiences; MODULE(S^2) Math of Doing, Understanding, Learning, and Educating for Secondary Schools; and Active Learning Mathematics.

Keywords: teacher recruitment, teacher training, active learning

Introduction

The major goal of the MTE-Partnership is to address the shortage of new secondary mathematics teachers who are "well prepared to help their students attain the goals of the Common Core State Standards for Mathematics (CCSS-M) (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) and other rigorous state mathematics standards" (Martin & Gobstein, 2016, p. 2). This paper explores one internship program for STEM undergraduates that touches on three critical aspects of this issue: providing a teaching experience that might enable us to recruit STEM majors to consider teaching, providing authentic teaching experiences that can support productive habits of mind for teaching, and training STEM majors to teach using active learning in classrooms.

Background of the Program

The use of instructional student assistants (ISAs; a pay classification for undergraduates used on the San Diego State University campus) to teach breakout sections for precalculus was new to our department. Prior to our use, ISAs were hired to grade papers, run small sections of supplemental instruction, and help in other instructionally related tasks. However, they had never been allowed to actually teach as part of a credit-bearing course. Therefore, we were cautious as we planned the format of the class, the ISAs' role definition, their preparation and responsibilities, and the active learning activities that the ISAs were asked to implement in their sections.

Format. Prior to this program, precalculus was taught in lectures containing 150 students that met for 50 minutes three times per week. This was less than optimal for incoming freshmen who are generally in need of more attention, of the type a smaller, more intimate setting where people would notice absences and encourage more talk among students could provide. Therefore, we chose to eliminate one of the lecture sessions and form five breakout groups limited to 30 students each (see Figure 1). The goal of these sessions has been shifting. At the outset, we tried to structure lessons that included applications of the precalculus material to real-life applications. After four PDSA cycles, the emphasis has shifted more toward creating experientially real activities in which students can engage in mathematical argumentation and exploration with an implicit goal of developing more robust mathematical mindsets.

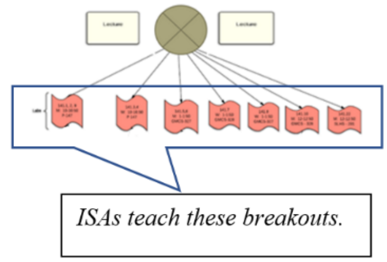


Figure 1. ISA breakout groups.

Role definitions. As undergraduates, the ISAs are not instructors of record. As “near peers,” we see their role as a broker between the collegiate world and the rather difficult life of first-time freshmen. In particular, we hoped ISAs would serve as STEM role models (Nickerson et al., 2017). Each ISA ran two breakout sessions, attended lecture, graded approximately 60 students’ homework and tests (although not their own students), and reported attendance to the instructor of record.

Preparation and training. The ISAs are required to attend three full days of pedagogical training during the semester prior to their teaching. About half of this time is spent learning about teaching ideas alongside the GTAs. The remaining time was spent with the director discussing the specific pedagogical goals and mathematical content knowledge needed to implement the activities. For example, during one of these training sessions, each of the ISAs got up before a small group and role-played how they would introduce a topic. Then the other ISAs would pretend to be students offering correct and incorrect answers. The group discussed pedagogical techniques such as avoiding the Elicitation-Response-Evaluation pattern when leading discussions. The student leader cohorts also met weekly with the program director to discuss the following week’s lesson plan, the prior week’s successes and opportunities for growth, the calculational and conceptual ideas underlying the mathematics to be covered, and ways to improve the program in general. The overall question we seek to answer is: what effects did this experience have on the participants’ identities and mathematics teachers and their views of active learning?

Conceptual Framework: Developing Identities for Mathematics and Teaching

We are currently developing a framework to conceptualize how to measure the effectiveness of the ISA program. Our view is that these ISAs develop identities for themselves both as teachers (while teaching and planning) and as mathematicians (while they are studying). Therefore, we attempt to integrate research regarding the development of one’s mathematical identity and one’s teaching identity.

One of the most prominent efforts to support the development of students’ mathematical identities is run by Jo Boaler, who bases some of her work on the mindset theory developed by Carol Dweck (2006). In her work, Boaler (2015) claims that mathematical skills – and by extension mathematical identities – are not fixed; the experiences we have in life are much more influential to our growth than the size or potential we have when we are born. Math geniuses are not “born,” they develop through passion and hard work. To encourage a mathematical mindset within their students, teachers need to first believe in the tenets of widespread potential, and then act on this belief by emphasizing open-ended classroom activities with active learning, praising students for their perseverance and grit rather than using words such as "genius," and celebrating the value and importance of making – and learning from – mistakes.

Research on teacher professional development focuses on the idea that the ongoing construction of one's identity as a teacher is a critical component of personal growth. While prospective teachers look forward to making the physical shift from being students of education to teachers in their own classrooms, their mental transition often takes much more time and evolves as they engage in increasingly authentic practices in the field (Pittard, 2003). One of the most often-cited impediments to this transition is the mismatch between pre-service teachers' experiences with coursework and their practicum experiences. This mismatch can be addressed by providing experiences all along what Grossman (2010) calls the "authenticity scale." For prospective teachers (or STEM students who may consider teaching), engaging in these authentic experiences with appropriate supports and feedback enables them to build both skill and confidence.

This framework guides our basic question: Do STEM majors who participate in the ISA program report differences in their development of a *mathematics teacher identity* when compared with prospective teachers who did not participate?

Alignment to MTE-Partnership Networked Improvement Community methodology (PDSA cycles)

Our work aligns with the MTE-Partnership goal of addressing the teacher shortage by engaging both majors and non-teaching majors in the authentic activity of teaching in a college-level active learning setting. We have run four iterations of the PDSA cycle, reflecting and changing as we went along. The main changes fall within two categories: nature of the lab activities and training of the ISAs. When we first began, our goal was to bring more application tasks into the teaching of precalculus concepts. Thus, we created a lab focused on developing a quadratic model of a ball rolling down a plank and a study of pH to exemplify a use of logarithms. After talking with the students and ISAs, we slowly began to focus more specifically on the social component of engagement rather than the real-life applications. One of our greatest successes was a lab that involved the simulated spread of a virus using successive coin tosses among the students. This was fun because the data was real and compiled by the group as a whole, and never looked the same between lab sections. However, as a visitor pointed out, the students were actively engaging in the *collection* of the data, but not in the creation of the model. This was a terrific insight and one that has focused us on training the ISAs to make sure that students are the ones doing the mathematical heavy lifting. Of course, the ISAs rightly realized that if students had been hand-fed the models in all of the other labs, then they would wait for this one as well. Hence, our next iteration is going to focus more solidly on engaging students in *experientially* real tasks (which may or may not be real-life applications) with the goal of building math mindsets in the spirit of Boaler (2015).

Methods

Gathering information from ISAs who have graduated is very difficult, particularly as graduates do not always update their contact information with their alma mater. Given the difficulties, we determined a survey would be the best way to collect uniform data as a baseline. The desired pool of survey candidates included: all single-subject majors (undergraduates enrolled in the program designated for high school math teaching), including both those who served as ISAs (response rate 7 out of 12) as well as those who did not (response rate of 6 out of 22), and all applied math majors who served as ISAs (response rate of 4 out of 8).[1] Two email invitations were sent out in early May: one by the first author (a known name who coordinates the program) and one by the

[1] Most all ISAs worked more than one semester, hence the totals shown in Figure 1 are higher than the total pool referenced in the response rate.

second author (a peer and fellow ISA). All responses were blind, so we do not know the gender or ethnicity of the respondent pool.

Data coding proceeded by coding the Likert Scale responses using an interval scale of 4 (strongly agree) to 1 (strongly disagree).[2] Although still somewhat controversial, we believe that this coding makes sense because a shift from a 1 “strongly disagree” to a 2 “disagree” is roughly equivalent to a shift from a 3 “agree” to a 4 “strongly agree.” Therefore, while we did compute some averages, most analyses involved simple frequency counts. In addition, due to very small number of responses, percentages were not calculated.

Results

Our first question was to determine whether this program affected the ISA participants’ future plans to attend a teacher credential program. As shown in Figure 2, there were two ISAs who were applied math majors who now considered applying to a credential program, and a third who definitely decided to choose teaching as a career. It is also the case that one ISA, who was initially a single-subject major, then decided not to pursue a credential in teaching. This is also a positive outcome as some students need to find out before they enter a credential program that teaching is not for them. Comparing these results to the pool of single-subject students who were not ISAs, a larger percentage of those single-subject majors who were *not* ISAs were undecided about whether to go into a teacher credential program. The numbers are too small to make statistical claims; we present these outcomes as some of the possibilities when students are engaged as ISAs.

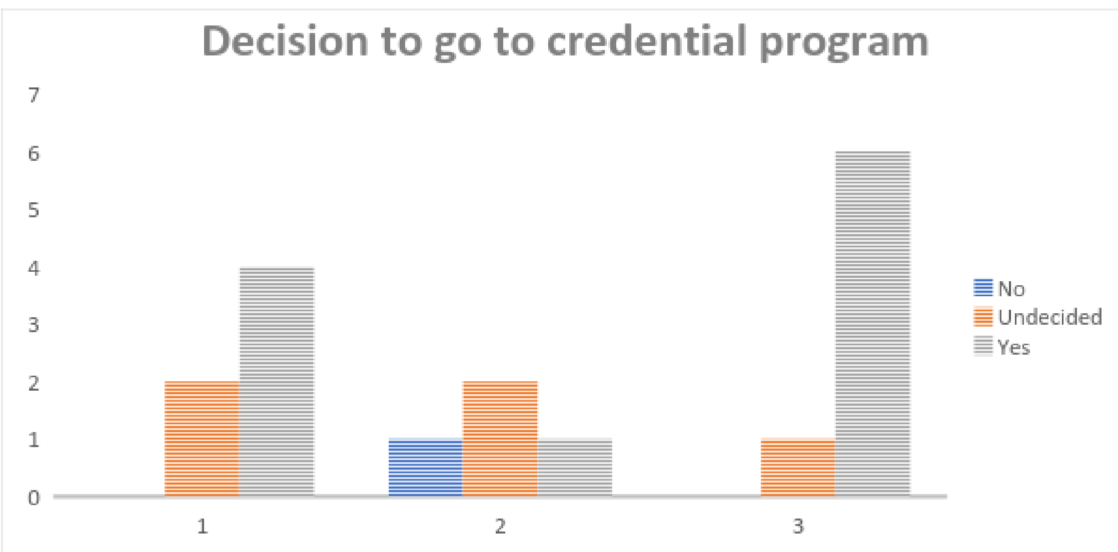


Figure 2. The decision to pursue teaching for ISA versus non-ISA students divided by major.

A second goal of the survey was to identify which of the various teaching opportunities within and beyond the ISA program and single-subject curriculum were most influential in students’ development of teaching and mathematical identities. The experiences we considered, ordered from most to least authentic (Grossman, 2010),

[2] This practice is controversial in some fields, but quite common in educational research. See *Is a Likert-type scale ordinal or interval data?*. Retrieved from: https://www.researchgate.net/post/Is_a_Likert-type_scale_ordinal_or_interval_data

were (1) serving as an ISA, (2) tutoring in some other capacity, (3) watching a class through a state of California required Early Field Experience, (4) completing the capstone course (Math 414- required for all prospective teachers), and (5) doing some other work (e.g., working in a school as an aide or tutor, or, more likely, any paid position such as barista or makeup artist).

Table 1 uses conditional formatting (red as lowest, green as highest) to highlight the experiences that respondents rated as influencing their thoughts about teaching. As can be seen, *work* (not tutoring) was the experience most often cited by the non-ISA group as influencing their thinking about teaching. In contrast, all of the students in the ISA group cited being an ISA as an influence in their views about teaching. A majority of the ISAs also cited their teaching as being a source for experiencing the satisfaction of helping a student understand a topic and many said that they felt that they had influenced learners. Researchers have cited intrinsic motivators such as these to be particularly important considerations for those choosing a career in teaching (cf., Richardson et al., 2013). Thus, more ISAs (who were single-subject majors) identified the ISA experience as providing opportunities for learning about teaching than any of the other aspects of the single-subject program, including working as a tutor, observing classrooms in an early field experience and taking the capstone course.

Table 1

The various influences and sources for experiences within the single-subject math program

	Non ISA						ISA					
	ISA	Tutor	EFE	414	Work	n/a	ISA	Tutor	EFE	414	Work	n/a
I felt inspired to continue pursuing teaching as a career.	0	1	1	2	4	0	5	2	3	8	9	2
I have learned new pedagogical skills.	0	1	1	2	1	2	11	6	2	3	1	1
I made an impact on the student(s) I interacted with.	0	2	2	0	3	1	9	8	3	0	3	1
I thought about mathematics conceptually.	0	0	0	1	3	2	10	6	3	4	1	1
I have increased my confidence in my ability to teach mathem...	0	1	2	1	4	1	11	9	3	2	2	1
I saw students performing algorithms but not understanding the logic behind them.	0	1	1	0	1	3	9	6	4	0	1	1
I considered becoming a teacher.	0	1	1	1	4	1	10	7	3	3	3	1
I questioned whether I wanted to be a teacher or not.	0	0	0	1	3	2	5	1	1	1	2	6
I realized how much more work teaching is that it appears.	0	0	2	0	1	2	10	1	4	3	3	1
I've experienced the satisfaction of a student saying they now understand a topic.	0	2	2	0	2	2	12	8	2	0	2	0
I've decided that I do not want to be a teacher.	0	0	0	0	0	5	1	0	0	0	1	10

Our third area of interest in this preliminary work was to explore any differences between the math teaching identities of the ISA and non-ISA groups. Using questions that reflect the major ideas of Boaler's work, we asked several questions about various teaching practices.

Strand 1: Clear Lecturing. One strand of questions focused on whether a teacher should present lectures in clear, step by step ways. Given that these prospective teachers learned effectively from lectures as math students, both the ISA and non-ISA groups strongly agreed with all items relating to presenting a clear lecture. This is not what we had hoped, but it may have been that students were contrasting *clear lecturing* with *unclear* *lecturing* rather than with more active learning strategies, and thus agreeing with clarity in mathematical expectations.

Strand 2: Expectations for Students. We asked several questions relating to the prospective teachers' expectations for how students should engage with mathematics in breakout sessions. These were based largely on the Common Core Standards for Mathematical Practice. Other items focused on equitable teaching practices, such as: I will only call on students who raise their hands. I don't think it's fair to expect everyone to be ready to participate.

Strand 3: Growth Mindset for Teaching. We applied Dweck's view (i.e., geniuses are not born, but emerge through practice) to the development of "good teachers." Here, we saw an encouraging difference: the prospective teachers who had been ISAs disagreed with this statement more than prospective teachers who did not have the ISA experience. As shown in Figure 3C, this strand showed the largest differences. The interquartile range for the ISA was much smaller than for the non-ISA group. This indicates that there was a similar feeling among ISAs that teachers can become better.

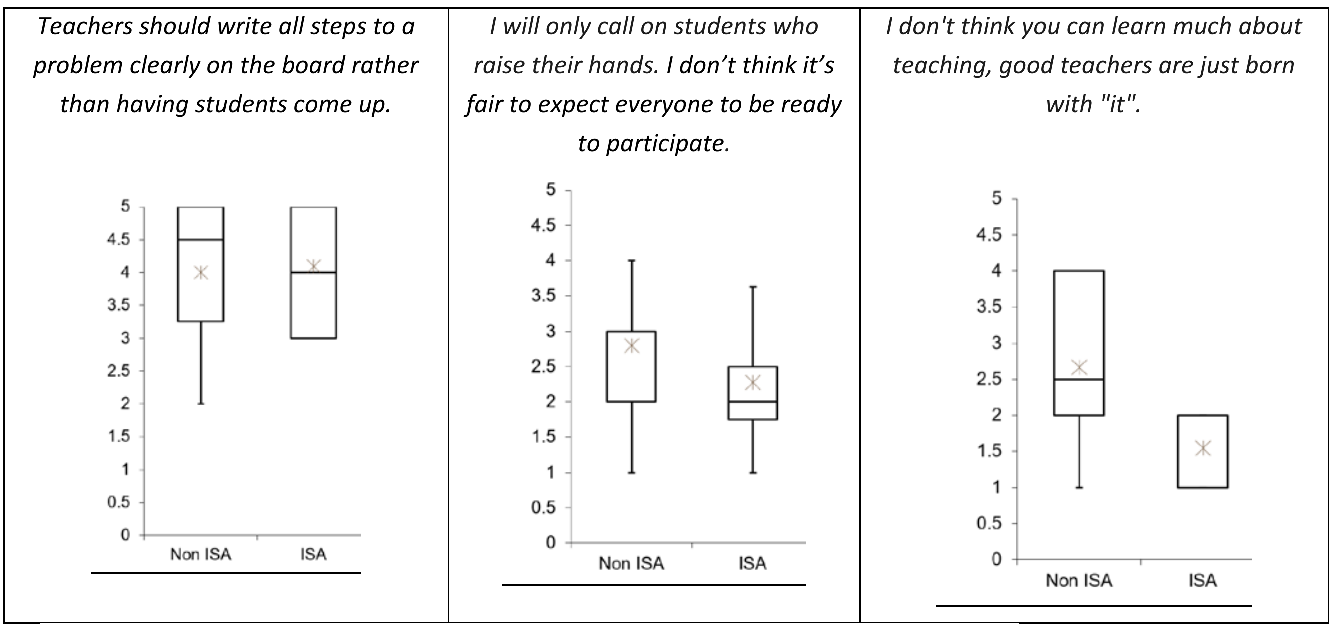


Figure 3. Box-and-whisker plots showing results from ISA and non-ISA survey respondents.

Conclusion

We have learned a great deal from this work and are encouraged to keep the ISA program going. We have found that it provides authentic opportunities for ISAs to learn new pedagogical skills, feel the intrinsic satisfaction of helping peers, increase their confidence in mathematics, and gain insights into the amount of work involved in teaching. These benefits convinced at least one applied math major to choose a career in teaching, and for two others to consider applying for a credential program. These findings impact the field of teaching in that we are providing some more experienced and curious math teachers for the local partnership. It is also a win for our institution because our students receive help and support from near peers—who serve as influential role models (see Nickerson et al., 2017). The department benefits since hiring ISAs costs less than half the cost to hire graduate teaching assistants (which are in short supply). Our next steps involve focusing on working with client disciplines to develop more appealing labs, and to increase the amount of training for the ISAs in the form of pre-semester help (featuring presentations from alumni ISAs) and in-semester feedback to support their development of fluency with discrete teacher moves such as asking higher-order questions.

For More Information

Please contact Janet Bowers, *San Diego State University*, Jbowers@mail.sdsu.edu.

References

Boaler, J. (2015). *Mathematical mindsets: Unleashing students' potential through creative math, inspiring messages and innovative teaching*. San Francisco, CA: Wiley.

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.

Dweck, C. S. (2006). *Mindset: The new psychology of success*. New York: Random House.

Grossman, P. (2010). Learning to practice: The design of clinical experience in teacher preparation. Policy Brief: AACTE. Retrieved from http://www.nea.org/assets/docs/Clinical_Experience_-_Pam_Grossman.pdf (Accessed 06/05/17)

Martin, W. G., & Gobstein, H. (2016). The MTE-Partnership story as revealed through its conferences: An overview of the partnership and its 2016 conference. In B. R. Lawler, R. N. Ronau, & M. J. Mohr-Schroeder (Eds.), *Proceedings of the fifth annual Mathematics Teacher Education Partnership conference* (pp. 2-9). Washington, DC: Association of Public and Land-grant Universities.

Nickerson, S., Bjorkman, K., Ko, S. J., & Marx, D. (January, 2017). Identification matters: Effects of female peer role models differ by gender between high and low mathematically identified students. Paper presented at the *Twentieth Annual Conference on Research in Undergraduate Mathematics Education.* San Diego, CA.

Pittard, M. M. (April, 2003). *Developing identity: The transition from student to teacher*. Paper presented at the Annual Meeting of the American Educational Research Association. Chicago, IL.

Richardson, P. W., Klusmann, U., Kunger, M. Beyer, M., & Baumer, J. (2005). Motivations for choosing teaching as a career: An international comparison using the FIT-Choice scale. *Teaching and Teacher Education, 28*, 791-805.

An Early Semester Mastery Activity and Intervention in First-Year Calculus

Allan Donsig, University of Nebraska-Lincoln, adonsig@unl.edu
Nathan Wakefield, University of Nebraska-Lincoln, nathan.wakefield@unl.edu

Abstract

Success in first-year mathematics courses is essential for students to pursue STEM careers, including teaching careers. We investigate a mastery activity given during the first two weeks of a first-year calculus course at the research site. Previous work showed a model using this activity in College Algebra, together with ACT and high school rank, was predictive of student success in precalculus. Here we do a similar analysis for such an activity in calculus, including an intervention for students who do not complete the activity. We also investigate the intervention's effectiveness. These results show that the early mastery activity, especially when combined with other indicators of mathematics readiness, is useful in identifying students at risk of failing calculus. Moreover, descriptive statistics suggest that students who participate in the intervention are more successful than expected, based on their academic backgrounds and other college grades.

Keywords: calculus, mastery grading, diagnostic activity, undergraduate mathematics, academic retention

Introduction

Historically, introductory STEM courses, including first-year calculus, struggle with high D-Fail-Withdraw rates (DFW; the percentage of students earning a grade of D or F, or withdrawing from the course). According to Bressoud and Rasmussen (2015), among students at Ph.D.-granting institutions, the average DFW rate sits at 25 percent. These poor success rates drive away STEM majors, including potential STEM education majors. Improving student success in college calculus courses is necessary to increase the number of teachers, as recognized by the MTE-Partnership's decision to make Active Learning Mathematics (ALM) one of the five initial Research Action Clusters (RACs). Indeed, the ALM-RAC has an explicit goal of improving "student success with undergraduate mathematics, starting with the Precalculus through Calculus 2 sequence (P2C2)."

We study one aspect of a systematic effort to improve student learning in first-year mathematics courses at the research site, a large, public land-grant university in the Midwest: an early semester mastery activity, the Course Readiness Activity (CRA), which is an enforced review of prerequisite material, with multiple attempts possible during the first two weeks of the semester. A different version of the activity has been used successfully in College Algebra and was shown previously to predict student success in College Algebra (Wakefield, Champion, Bolkema, & Dailey, in press). Our first question, building on this previous paper, is:

Question 1: What capacity does a CRA in calculus have for identifying students who are at risk for failing a calculus course, beyond known identifiers, such as high school grades or ACT Math subscore?

The CRA has the additional benefit of engaging students early in the semester. Since there are multiple attempts, the pattern, timing, and performance changes for these attempts provide valuable information about a student's engagement.

Beyond identification, if some students are at-risk, how can that risk be reduced? In the studied course, a simple remediation effort was offered to students who did not complete the CRA. This leads to our second research question:

Question 2: Did this intervention improve outcomes for those who participated?

Since students chose for themselves whether to participate, a major challenge in answering this question is whether such students are systematically different from those who did not participate in the remediation.

Description

Overview of CRA

The first Course Readiness Activity (CRA) at the research site was introduced in College Algebra, based on a similar Gateway exam in the University of Michigan's Precalculus and Calculus I courses. There are now CRAs in four first-year mathematics courses, each of which covers appropriate prerequisite material for that course, at the depth of understanding that is needed for success.

As an activity, rather than an exam, the expectation is that all students will successfully complete the CRA, i.e., it is not an assessment. Nor is the CRA used to revisit placement decisions. Students who fail to complete the CRA are not encouraged to drop the course.

One motivation for the CRA is that students' experience of college calculus convinces them that they were not properly prepared. In the MAA's *Insights and Recommendations from the MAA National Study of College Calculus,* Bressoud (2015) argues that while 80 percent of students enter college believing they are ready for calculus, by the end of the semester only 55 percent believed they were ready. Furthermore, this sample may be biased in that discouraged students would seem less likely to complete the end-of-semester survey and, indeed, significantly fewer students completed the end-of-semester activity. Thanheiser, Philipp, Fasteen, Strand, & Mills (2013) highlight the importance of showing pre-service teachers that their current understanding of mathematics is limited and that they have more to learn. While not a perfect parallel, one goal of the CRA is to encourage students to review and master prerequisite material and to achieve the deep understanding that is essential for effective application of this material in calculus.

Description of CRA

The Calculus CRA consists of 15 questions chosen from such topics as cancellation laws, equations of lines, rational expressions, exponents, inequalities, polynomials, domain and range, piecewise functions, function notation, graphs, logarithms, and trigonometry. There is also a word-problem/modeling question.

An in-class paper CRA is given early in the first week of classes. Students are told of the CRA before the semester starts and course instructors devote a little class time to preparing for the CRA. Instructors grade the CRA and post scores the same evening. Mastery grading is used; that is, students who receive a passing score (80 percent) are given full credit (40 points on roughly an 800-point grading scale). Students who do not achieve 80 percent on the paper CRA can take the CRA online in a university testing center once per day, for the first two weeks of the semester. The online CRA questions are either algorithmically generated or drawn from pools of varied questions covering the same issue. For example, a true-false question on cancellation laws is selected at random from a mix of identities and popular fallacies. The online exam is machine graded with the same requirements as the paper one, except that students receive immediate feedback. Each exam is generated independently, without reference to the student's previous attempts. Students are strongly encouraged to discuss their work with an instructor or a tutor in the tutorial center, particularly if they are unsuccessful in multiple attempts online.

Instructors regularly remind students to complete the CRA. Nevertheless, there is still a contingent of students who do not pass the CRA. Improving success rates means helping struggling students engage with the material more effectively. To this end, the department developed a simple intervention: students who did not pass the CRA were given the opportunity to meet with their instructor and discuss strategies for being more successful in the course. Students who met with their instructor were given back points at their instructor's discretion.

To analyze the predictive power of the CRA, CRA outcomes were compared to overall course grades, scores on individual exams, and institutional registration data, such as ACT Math sub-score and high school percentile rank. In the fall of 2016, complete data was available for 735 students (out of a total enrollment of 837). Among the 735 students in the calculus sample, there were 283 females and 434 males. All but 74 were either 18 or 19 years old and all but 98 were first-time, first-year students. For ethnicity, 79 percent were White/Non-Hispanic, 7 percent Hispanic, 5 percent Asian, 2.3 percent African-American, and 3.1 percent multiple races. The average ACT Math sub-score was 26.4.

Table 1 shows the number of students in each CRA outcome and the course performance for each group. There were five possible outcomes on the CRA: “Passed on Paper” (showed mastery on the paper CRA), “Passed Online” (did not show mastery on the paper CRA exam, but did so on the online exam), “Intervention” (did not achieve mastery but met with instructor to develop a plan to be successful), “Fail” (did not achieve mastery, attempted the CRA online, and did not meet with instructor to develop a plan to be successful), and “Abdicated” (did not achieve mastery and never made an attempt online). Course Success Rate is the proportion of students who achieved a grade of C or better. Exam Success Rate is the proportion of students whose average on course exams, that is, three semester tests and the final exam, was a C (i.e., 70 percent) or better. The course grade was made up primarily of exam scores, but also a variety of items, such as quizzes, participation, and online homework, including, as a small component, the CRA. For statistical analysis, exam performance is used to ensure independence between the CRA and dependent variables.

Table 1

CRA & Course Success (N=735)

CRA OUTCOME	PROPORTION OF STUDENTS	COURSE SUCCESS RATE	EXAM SUCCESS RATE
PASSED ON PAPER	214 (29%)	92%	86%
PASSED ONLINE	397 (54%)	86%	58%
INTERVENTION	30 (4%)	67%	43%
FAILED	70 (10%)	34%	19%
ABDICATED	24 (3%)	20%	17%

MANOVA Analysis

To answer the first research question, a multivariate analysis of variance (MANOVA) was performed using ACT, high-school percentile, and CRA performance as explanatory variables and exam performance as dependent variables. Visual inspection of the matrix of scatter plots for each exam revealed elliptical scatter plots between dependent variables, correlation between each dependent variable, and a hook shape along each of the diagonals (q-q plot). The elliptical scatter plots suggest correlation between the dependent variables. The hook shape on the diagonal reveals some left skew in the distributions, as is common with exam data. However, the left-skew issues can be overcome by the large sample size. Hence, MANOVA is a reasonable statistical test; see Figure 1.

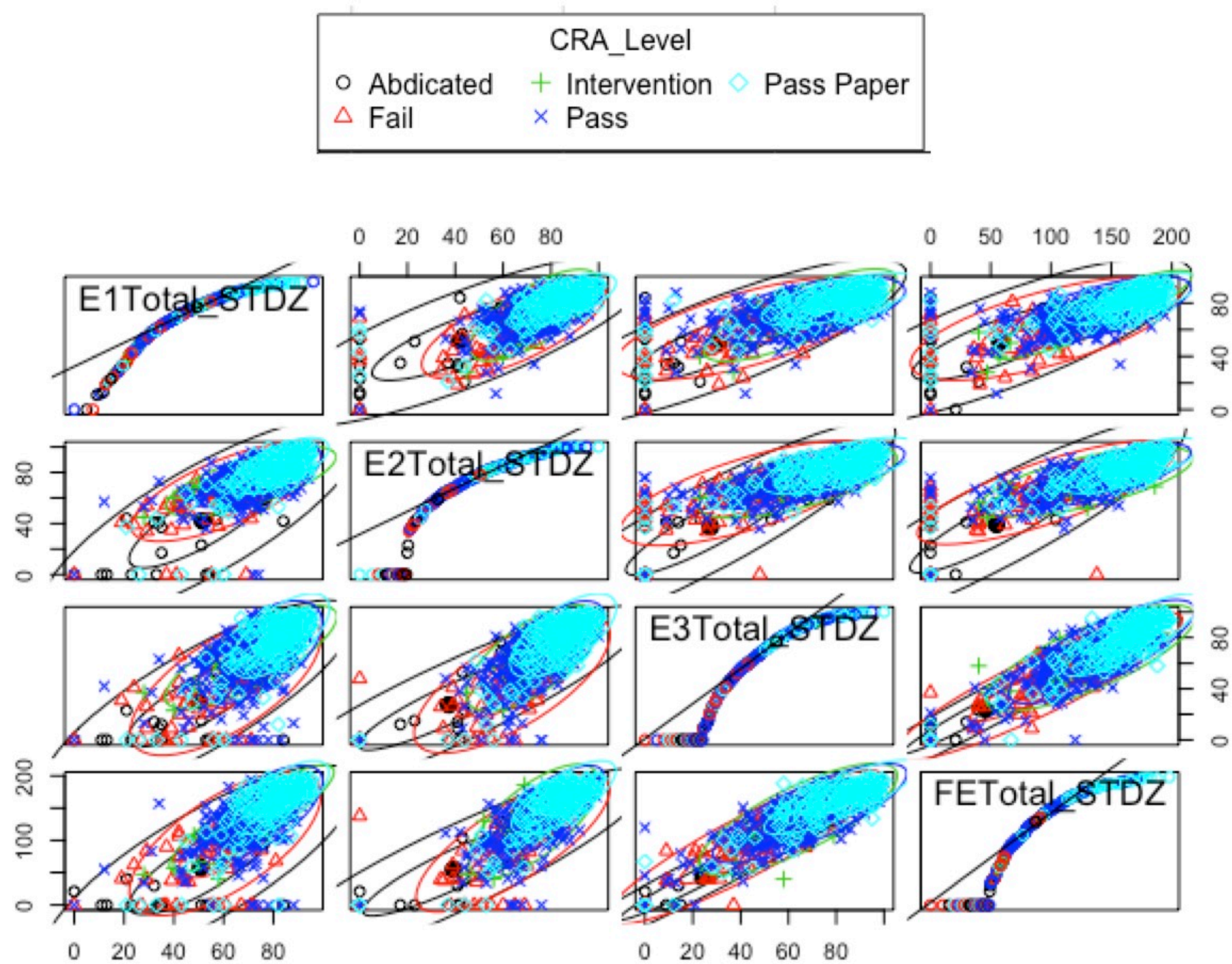


Figure 1: Matrix of scatter plots: Exam 1, Exam 2, Exam 3, Final Exam.

After omitting non-significant interaction effects, the MANOVA suggested that there were significant main multivariate effects from each of the explanatory variables on exam scores (p<.001 for ACT Math, HS percentile, and CRA=Pass Paper, Pass, Intervention; p<.01 for CRA=Fail; p<.05 for CRA=Abdicated; multiple R^2=.39, .36, .39, and .40 for the four exams, respectively). Type II multivariate tests for individual explanatory variables indicate that ACT math performance, high school percentile, and CRA performance are all significant at a level of p<0.001 in all four of Pillai, Wilks, Hotelling-Lawley, and Roy's greatest Root.

While it is commonly accepted that ACT mathematics sub-score and high school percentile affect math course outcomes in college, our analysis using MANOVA suggests that the CRA has additional capability of identifying students who are at risk for failing the course early in the semester. That is, the CRA is telling us something more than we know from just the ACT mathematics sub-score and high school percentile. In fact, only 18 percent of students who either failed or abdicated on the CRA successfully completed the course whereas more than 66 percent of students who passed the CRA on paper or online successfully completed the course. Beyond the CRA, high school percentile and ACT math sub-score also provide key indicators of future success.

A natural question is, "What does the CRA measure?" One aspect that the CRA certainly measures is mathematical content. However, it appears the CRA measures more than mathematical content. The CRA correlates with exam performance. However, the CRA does not appear to correlate with ACT Math sub-score. In fact, running a MANOVA with the CRA outcome and the ACT math sub-score as explanatory variables results in CRA=Pass, and CRA=Pass Paper as the only significant effects ($p<0.05$ and $p<0.01$ respectively). We argue that this is because the CRA, particularly the online CRA, is also measuring engagement in the course.

Analysis of Intervention

We turn now to the second research question: Did this simple intervention improve student success? Recall that the intervention was the opportunity to meet with the instructor and discuss strategies for being more successful in the course, with strong encouragement to use the tutorial center. (Unfortunately, we do not have data about these students' use of the tutorial center.) Students who met with their instructor were given back the CRA points at their instructor's discretion, so participation in the intervention is not fully independent of course grade. Only 30 students participated in the intervention out of the 100 students who attempted the online CRA and did not pass it. As Table 1 shows, students in the intervention were much more likely to have a C or better in the course and more likely to have a C or better average on their exams.

Since exam performance does not include any points for the CRA, we look at box and whisker plots for average exam score and for final exam percentage by CRA outcome, in Figures 2 and 3. Both figures show that students who participated in the intervention did significantly better. In particular, all students in the intervention group did better, by either measure, than the bottom quarter of those who did not participate in the intervention.

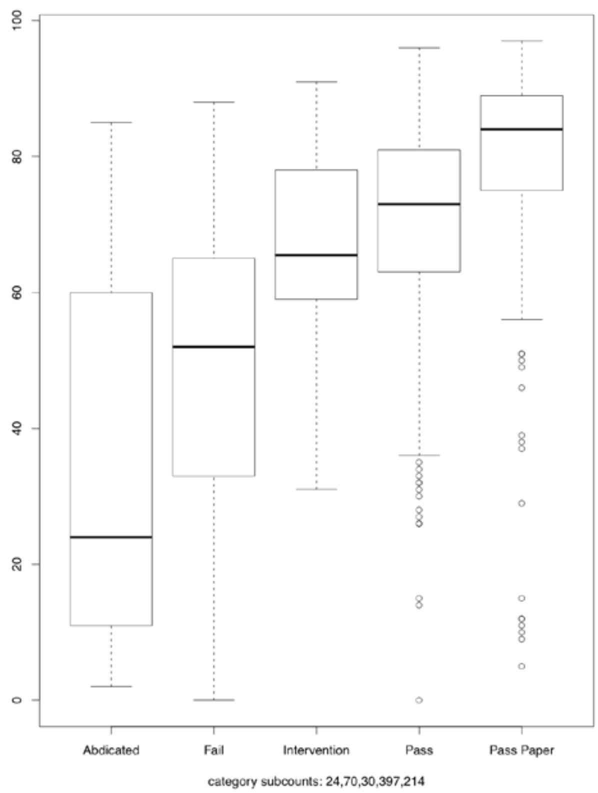


Figure 2. Exam average by CRA category.

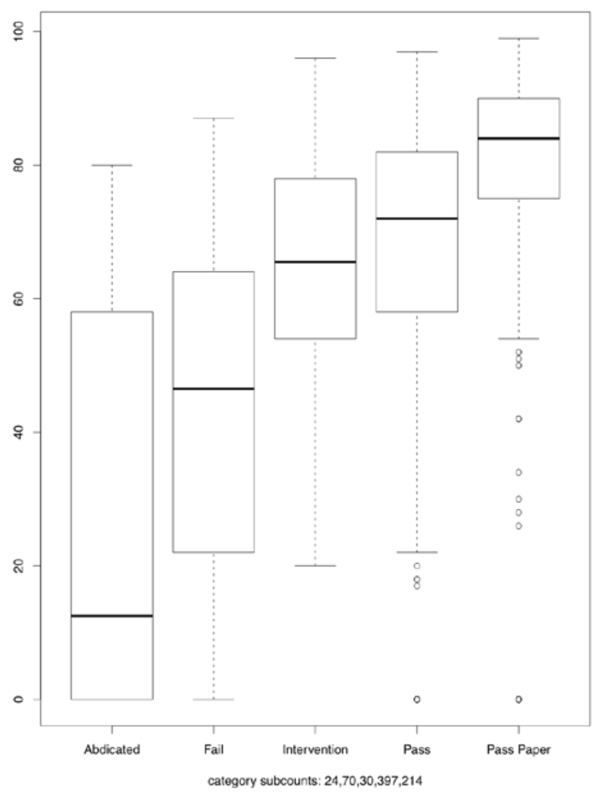


Figure 3. Final exam percentage by CRA category.

An almost immediate concern, given that students self-selected to participate in the intervention, is that there is some significant difference in the background or engagement level of the two groups of students, so that those who participated in the intervention would have been more successful, with or without the intervention. While it is impossible to answer this definitively in the absence of a randomized trial, we have some evidence that the two groups of students are similar in important ways. Consider the box and whisker plots for ACT mathematics sub-score and high school percentile rank by CRA outcome, in Figures 4 and 5. In each case, the fail and intervention groups appear broadly similar, although the intervention group has a slightly higher average in each case. But the substantial difference in Figures 2 and 3 is not likely explained by these small differences.

Similarly, we can compute these students' semester GPA, excluding the calculus course. We take this 'nonmath GPA' as a proxy for a student's overall academic success in college. Looking at box and whisker plots for nonmath GPA by CRA outcome, students in the Intervention group have a similar average to those in the Fail group, although with a somewhat higher distribution overall. Therefore, the Intervention students are not simply better at college or, at least, not sufficiently better to explain the large differences in Figures 2 and 3.

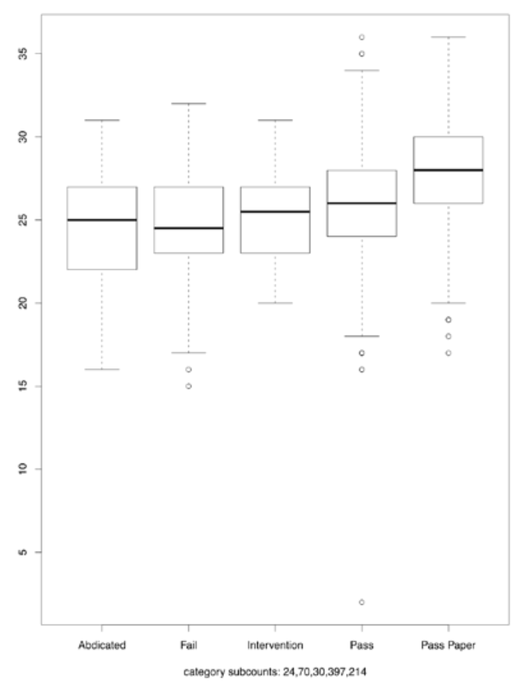


Figure 4. ACT Math subscore by CRA category.

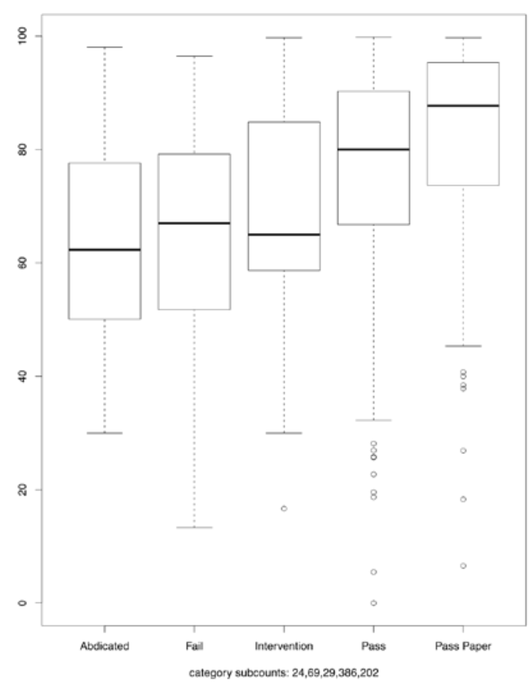


Figure 5. High school percentile rank by CRA category.

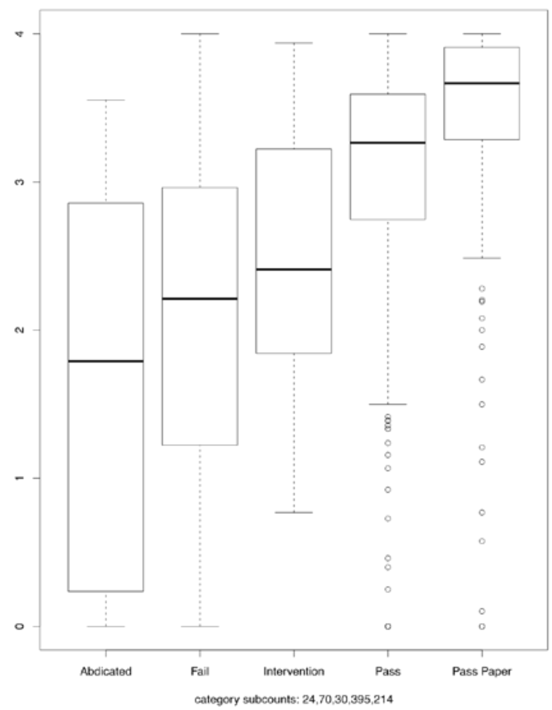


Figure 6. Non-math GPA by CRA category.

Conclusion

Based on the previous study for the College Algebra CRA, we expected that a Calculus CRA would also be able to identify at-risk students. Moreover, we introduced a simple intervention to help those students. If we accept that the CRA is also measuring engagement, then interventions should aim to improve students' engagement with the course.

A statistical analysis of the students' performance demonstrated a strong relationship between the students' CRA performance and their subsequent achievement in the course. The MANOVA analysis shows the CRA provided additional information beyond students' prior academic record. Descriptive statistics suggest the intervention improved grades for participants.

Based on our experience with the CRA, we have a few suggestions for anyone desiring to implement such an activity. To begin, two warnings: first, although students can take the exam once per day for the first two weeks of the semester, many wait until close to the deadline to make their first online attempt at the exam. Second, we framed the CRA as an activity and emphasized that all students should complete it, to avoid anxiety about an "exam," particularly an exam in the first few days of class. Furthermore, by emphasizing the benefits of starting class work early, we try to both reduce anxiety and improve engagement. We often remind students that they have the opportunity to repeat the activity multiple times until they are successful. We want students to use the activity as a way to start the course off with a good grade. For those willing to try, the CRA provides a first step toward success in calculus.

Finally, an important aspect of the CRA is that it provides a basis for engaging at-risk students based on their work in the course, rather than asking them to participate based on prior academic results. Indeed, we don't have access to such information, nor do we wish to "label" students in ways that might compromise instructor's expectations. We continue to refine both the CRA and the intervention, with the goal of ensuring that students, even those at risk of failure, know what they need to do to succeed and are encouraged to do so.

For More Information

Please contact either author; for details of CRA, please contact Nathan Wakefield.

References

Bressoud, D. (2015). The calculus students. In D. Bressoud, V. Mesa, C. Rasmussen, (Eds.) *Insights and recommendations from the MAA national study of college calculus* (pp. 1-16), Washington, DC: Mathematical Association of America.

Bressoud, D., & Rasmussen, C. (2015). Seven characteristics of successful calculus programs. *Notices of the AMS*, *62*(2), 144-146.

Thanheiser, E., Philipp, R., Fasteen, J., Strand, K., & Mills B. (2013). Preservice-teacher interviews: A tool for motivating mathematics learning. *Mathematics Teacher Educator*, *1*(2), 137-147. doi:10.5951/mathteaceduc.1.2.0137

Wakefield, N., Champion, J., Bolkema, J., & Daily, D. (in press) Diagnostic and achievement effect of an early semester mastery activity in college algebra. *International Journal for Research in Undergraduate Mathematics Education.*

SEMINAL: Preliminary Findings on Institutional Changes in Departments of Mathematics

Wendy M. Smith, University of Nebraska-Lincoln, wsmith5@unl.edu
David C. Webb, University of Colorado, Boulder dcwebb@colorado.edu
Janet Bowers, San Diego State University, jbowers@mail.sdsu.edu
Matt Voigt, San Diego State University, mkvoigt@gmail.com
The SEMINAL Team[1]

Abstract

Student Engagement in Mathematics through an Institutional Network for Active Learning (SEMINAL) is a five-year IUSE grant from NSF (2016-2021). The goal of SEMINAL is to stimulate and better understand how to enact and support institutional change aimed at implementing active learning in undergraduate mathematics learning environments, focusing in particular on large-enrollment entry courses: precalculus to calculus 2 (P2C2). SEMINAL is being carried out in two phases. Phase 1 consists of case studies at six institutions that have a record of successfully implementing Active Learning Mathematics (ALM). These institutions were selected to represent different institutional settings and diverse student demographics. Phase 2 consists of longitudinal, incentivized case studies of nine diverse institutions that will infuse active learning into the P2C2 sequence. Overall, Phase 1 will offer the field a retrospective account of ALM models of change that worked. Phase 2 will develop theory and insights into the processes by which change focused on ALM can unfold over time, along with affordances and constraints related to institutional change. Phase 1 data collection was completed in spring 2017, including site visits to the six targeted mathematics departments. In this article, we share both SEMINAL's theory of change for mathematics departments, and preliminary findings from the recent site visits. We discuss emerging features and aspects of the departmental cultures at these six institutions and ways in which the research of and support for ALM in the P2C2 sequence addresses the mission of the MTE-Partnership.

Keywords: active learning mathematics, improvement science, networked improvement community, institutional change

Introduction

Student Engagement in Mathematics through an Institutional Network for Active Learning (SEMINAL) is a five-year collaborative grant from NSF (2016-2021); the collaborative partners are the Association of Public and Land-grant Universities (APLU), the University of Colorado Boulder, the University of Nebraska-Lincoln, and San Diego State University. The goal of SEMINAL is to stimulate and better understand how to enact and support institutional change aimed at implementing active learning in undergraduate mathematics learning environments,

[1] In addition to the individuals named as authors, the SEMINAL team includes: Howard Gobstein (APLU); Robert Tubbs, David Grant and Nancy Kress (University of Colorado Boulder); Chris Rasmussen, Michael O'Sullivan, and Naneh Apkarian (San Diego State University); Allan Donsig, Nathan Wakefield, and Molly Williams (University of Nebraska-Lincoln); and John Sutton (RMC Research).

focusing in particular on large-enrollment entry courses: precalculus to calculus 2 (P2C2). Related to the Math Teacher Education Partnership (MTE-Partnership), SEMINAL works broadly to address the quality of undergraduate mathematics courses by understanding the institutionalization of cultural shifts in mathematics departments that value more active learning instructional strategies. We would argue that as mathematics departments improve student learning in the P2C2 sequence, greater numbers of students will be more motivated to pursue mathematics majors and those students who pursue secondary mathematics licensure will have more experiences of exemplary teaching and learning to draw from when they teach. Further, the SEMINAL collaboration and focus on institutional change at the department level has grown out of the MTE-Partnership Active Learning Mathematics Research Action Cluster (ALM-RAC). An *n*-dimensional problem cannot be solved with a 1- or 2-dimensional solution; SEMINAL takes a systemic approach to institutional change in mathematics.

A number of both small- and large-scale studies have shown that undergraduate students in active learning environments can learn more effectively in their classes, resulting in increased achievement and improved dispositions (Freeman et al., 2014; Henry, 2010; Laursen et al., 2014; Rasmussen & Kwon, 2007), particularly for underrepresented groups (Laursen et al., 2011). While these studies define active learning in broad terms relating to student activity, we define Active Learning Mathematics (ALM) as teaching methods and classroom norms that promote: (1) students' deep engagement in mathematical reasoning, (2) peer-to-peer interaction, and (3) instructor inquiry into student thinking (Rasmussen & Wawro, 2017). To support ALM, the curriculum should focus on key mathematical ideas, including the use of tasks that promote sense making and procedural fluency. Student activity should favor opportunities for them to propose questions, communicate reasoning, and share solutions in process. Instructor activity should showcase practices that promote student engagement and build on student thinking to advance the mathematical agenda. Undergraduate institutions are, by design, resistant to change (e.g., Birnbaum, 1991, 1999). From the organization of majors, to course syllabi, to expected classroom practices, change is challenging to implement and sustain. However, research on instructional change (Hayward, Kogan, & Laursen, 2015; Kezar, 2014) has shown that with well-articulated goals, leadership, and proper incentives, these traditions can be disrupted so that changes to the status quo can be enacted and sustained through key institutional supports that retain innovations as the new normal. We have witnessed this unfreezing-changing-sustaining process within Phase 1 math departments (e.g., Apkarian, Bowers, O'Sullivan, & Rasmussen, in press; Carreon, DeBacker, Kessenich, Kubena, & LaRose, 2017; Webb, Stade & Grover, 2014).

SEMINAL's primary research question is: What conditions, strategies, interventions, and actions at the departmental and classroom levels contribute to the initiation, implementation, and institutional sustainability of active learning in the undergraduate calculus sequence (Precalculus through Calculus 2) across varied institutions? We adopt an ecological framework to institutional change, envisioning changes nested in a variety of interrelated contexts: departmental, institution, and community cultures, as well as the knowledge and beliefs of all engaged stakeholders. Figures 1 and 2 illustrate our initial frameworks for the key components of change at the classroom and departmental levels.

SEMINAL is being carried out in two phases. Phase 1 consists of case studies at six institutions that have a record of successfully implementing Active Learning Mathematics (ALM) and that represent both diverse institutional settings and student demographics. The six institutions include the three research collaborative partners (outlined above) and three additional institutions (Sam Houston State, University of Illinois at Chicago, and the University of Michigan). Phase 2 consists of longitudinal, incentivized case studies of nine diverse institutions that will infuse active learning into the P2C2 sequence. Phase 2 institutions will be expected to work together in a Networked Improvement Community connected to the MTE-Partnership ALM-RAC. By applying improvement science to departmental and institutional change, Phase 2 institutions will engage in Plan-Do-Study-

Act cycles to engage in a process of continuous improvement of their high-enrollment undergraduate P2C2 courses.

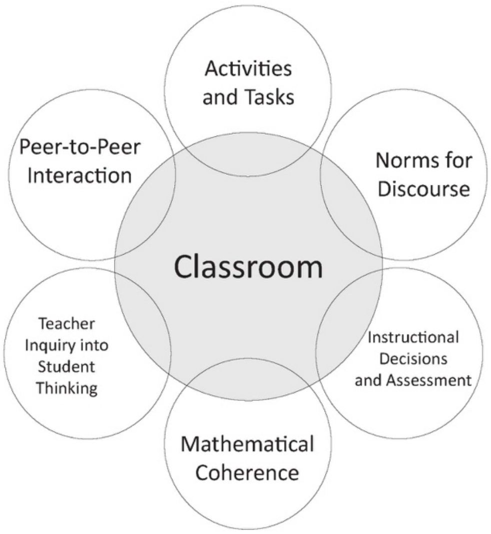


Figure 1. ALM at the classroom level.

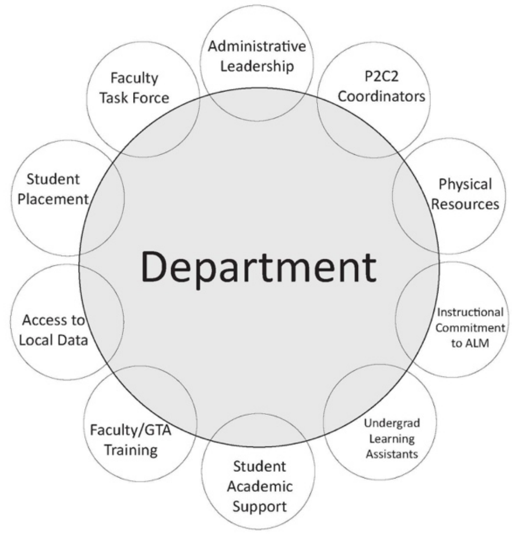


Figure 2. ALM at the departmental level.

Overall, Phase 1 offers the field a retrospective account of ALM models of change that worked. Phase 2 will develop theory and insights into the processes by which change focused on ALM can unfold over time, along with affordances and constraints related to institutional change. Phase 1 data collection was completed in spring 2017, including site visits to the six targeted mathematics departments.

Methods

SEMINAL research is studying institutional change in multiple settings, and at various stages of the change processes, through coordinated research and evaluation efforts. During Phase 1, members of the research and evaluation team conducted separate two-day site visits at each of six institutions whose mathematics departments were identified as having a sustained culture of active learning in P2C2 courses. Using a design research model to iteratively study institutional change at each research site, we are developing case studies of institutional change (Yin, 2003) in the diverse contexts. Each mathematics department implementing ALM will be one case.

To determine how classroom and departmental elements contribute to or serve as barriers to student success, it is important to define student success in high-enrollment undergraduate mathematics courses. In the short-term, student success is measured by student end-of-course grades to calculate the percentage of students earning a C (pass) or better, and student attitudes toward mathematics. Longer-term measures of student success include student retention rates in college, intentions to pursue STEM majors, and course-taking patterns (taking more mathematics courses in subsequent semesters).

Each of the six institutions being studied agreed to complete a survey designed to capture department culture and social networks. SEMINAL asks all P2C2 instructors to complete the PIPS+: Postsecondary Instructional Practices Survey, with additional demographic and SEMINAL-specific items (Walter, Henderson, Beach, & Williams, 2016). SEMINAL also surveys students in P2C2 courses, with an adapted version of PIPS+ for students (SPIPS+), to capture instructional practices, student intent to persist in STEM, and students' beliefs and attitudes toward mathematics in general and ALM in particular. During the site visits, SEMINAL teams conducted observations of

P2C2 courses, utilizing the Mathematics Classroom Observation Protocol for Practices ($MCOP^2$; Gleason & Cofer, 2014).

If institutional change to increase student success in mathematics were easy to accomplish, everyone would already be doing it. To determine the barriers that make this work challenging and the strategies that are employed to overcome these barriers, the institutional change processes at the research and collaborating campuses will be documented internally by the participating institutions and externally by case study teams that represent both researchers and the grant's external evaluator. The Phase 1 site visits mainly included interviews of a wide variety of P2C2 stakeholders at the classroom, department and campus levels. As affordances, constraints, and patterns of change emerge from cross-institutional analyses, we will articulate potential pathways for change for mathematics departments interested in improving student success in high-enrollment undergraduate mathematics courses. We will also investigate the extent to which formal and informal leadership at each institution at various levels influences the implementation of an ALM model in P2C2 mathematics courses. As analyses for Phase 1 unfolds further, we will use a grounded analysis (Strauss & Corbin, 1998), informed by our institutional frameworks to develop themes within and across our cases to develop models of institutional change for active learning that with inform our approach to Phase 2.

Preliminary Findings

Consideration of Institutional Context

Still in its first year, the SEMINAL research and evaluation teams are in the process of analyzing the data collected during Phase 1. Across year 2, analyses will be continued, and cross-case analyses will begin. One of our key initial determinations is that we needed to expand our change frameworks beyond the classroom and department levels, to seriously include the institution and community levels. Thus, during Phase 1 site visits, in addition to interviewing mathematics faculty and instructors, we also interviewed faculty in mathematics client disciplines (e.g., physics, chemical engineering). Figure 3 shows our revised framework, that considers ALM in the interrelated contexts of the classroom, department, institution, and community. Although Figure 3 shows nested contexts, all of these contexts interweave in complicated ways. The SEMINAL team is working to create diagrams to depict key features of institutional and community contexts. An early draft of key institutional contexts is shown in Figure 4; preliminary key community contexts are shown in Figure 5.

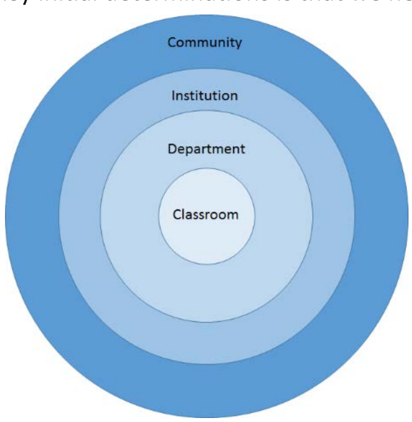


Figure 3. Relevant ALM contexts.

The communication norms of a campus seem to play a pivotal role in sustaining ALM. We have observed different norms for communication among departments, and among central administrators, deans, and department chairs. In all Phase 1 institutions, there were at least a few strong connections between the mathematics department and central administrators who value active learning.

Related to resources for instruction, Phase 1 institutions featured administrators (central administrators and department administrators) who were willing to pay the costs of improved instruction. It is more resource-intensive to have smaller classes or more instructors per course to implement active learning, compared to large lecture courses. Resources are also important at the community level. Departments moving toward ALM also incurred costs related to course redesign and instructor professional development. Resources for infrastructure, faculty, and students (including campus norms for housing and/or commuting) all influence the successful institutionalization of ALM.

Figure 4. Preliminary institutional contexts.

Figure 5. Preliminary community contexts.

SEMINAL is just beginning to explore identity as an institutional feature; it seems to encompass the university mission, research, teaching, departmental culture, and student population. Community identity also impacts ALM in P2C2 courses, including who takes P2C2 courses and how valuable it is for community members to be mathematically literate.

Placement

While the original SEMINAL framework identified student placement as a departmental context (Figure 2), we found this to be more of an institution-level context in some of the Phase 1 sites. More than one campus utilized math placement to also determine placement in introductory science courses (e.g., chemistry, physics). Also, at some campuses, the placement test (e.g., ALEKS) was determined by central administrators. No campus is completely satisfied with their placement procedures; many faculty who were interviewed expressed concerns that current placement procedures may be at odds with campus goals for increased equity. SEMINAL plans to continue to investigate placement procedures, especially as some participating campuses are changing these procedures.

As the ALM Research Action Cluster in the MTE-Partnership began to consider levers for change, unacceptably high D-Fail-Withdraw (DFW) rates were commonly cited. For at least two Phase 1 institutions, the rates of grades of DFW were the original impetus for change; for other Phase 1 institutions, dissatisfaction with calculus recitations was the original change point. As Phase 1 institutions examine their student data, including DFW rates and course-taking trajectories, another preliminary finding is that on some campuses a grade of C does not actually prepare a student well enough to pass the subsequent course. At one campus, the percentage of students who pass Calculus 1 after taking precalculus on campus increased by 10 percent after comprehensive implementation of ALM. However, this overall 63 percent passing rate in Calculus 1 by students who took precalculus at the college masks the fact that while about 85 percent of students who earned an A in precalclulus were able to pass Calculus 1, under 30 percent of students who earned a C in precalculus were able to pass Calculus 1. Given this finding, SEMINAL is seeking to explore course taking trajectory and grade data from all of the Phase 1 institutions, and to implement some PDSA cycles to investigate what policy changes could be made to address these findings.

Consideration of Community Context

By conducting site visits using an improvement science framework, the SEMINAL team collected information about the contexts of P2C2 courses. While our original hypothesis narrowed our scope to the classrooms and departments, the site visits convinced us we needed to consider both the broader institutional contexts and the community contexts. For instance, Sam Houston State University recognizes that many of their students are first-generation college students, which influences the design of community, campus, and department support structures. Finding ways to ensure students are able to negotiate housing and finances, enrollment in courses, and course-taking decisions that could make or break the completion of the mathematics major are understood and supported at multiple levels. Community contexts also arose for the University of Illinois Chicago, where the university has dual identities as both a research-intensive university and a community-serving institution for under-represented and commuter students. Being based in Chicago, they are in direct competition and impacted by other local universities, which has implications for their desire for high-quality P2C2 courses that meet their students' needs.

Conclusion

As we conclude Phase 1, SEMINAL is actively seeking proposals for institutions to participate in Phase 2. Institutions chosen will receive some project funds (approximately $50,000-100,000) to support efforts to enact institutional change related to implementation and/or scaling up of ALM in the P2C2 sequence. After selection of awardees is made in late 2017, Phase 2 institutions will participate in a networked improvement community, and will use the framework of improvement science, along with what will have been learned from Phase 1 of SEMINAL, to guide their change processes. This network will be connected to the MTE-Partnership ALM-RAC network, who have been working to institutionalize ALM on their campuses for the past five years.

The SEMINAL research and evaluation teams are also actively analyzing Phase 1 data, with the goal of creating a handbook of ALM and institutional change based on these analyses in 2018. Such a handbook will carefully describe the contexts of each of the six institutions, and then have sections about each of the key change features (at the classroom, department, institution, and community levels). SEMINAL plans to work with the MTE-Partnership network to disseminate findings, thus helping universities across the country improve their campus cultures related to ALM, and thus their P2C2 student outcomes.

Institutional change literature (e.g., Elrod & Kezar, 2016; Kezar, 2014) suggest a key reason effective practices fail to successfully scale up is when stakeholders ignore contextual features. SEMINAL believes for *n* institutions successfully implementing ALM, such instantiations of institutional change will take *n* different (but not disjoint) forms. A key challenge is understanding the contexts at the classroom, department, institution, and community levels, and determining which of those contextual features are key to implementing and sustaining positive changes. Improvement science seems to be a promising approach to effecting sustained institutional change to improve student outcomes in mathematics.

For More Information

- Website: http://www.aplu.org/seminal/
- Contact David Webb (dcwebb@colorado.edu) or Wendy Smith (wsmith5@unl.edu) for general inquiries. Contact seminal@aplu.org for questions about the Phase 2 opportunity.

Acknowledgments

SEMINAL is supported in part with a collaborative grant from the National Science Foundation (DUE-1624643, DUE-1624610, DUE-1624628, and DUE-1624639) to the Association of Public and Land-grant Universities, the University of Colorado Boulder, the University of Nebraska, and San Diego State University. All findings are those of the authors and not necessarily of the National Science Foundation.

References

Apkarian, N., Bowers, J., O'Sullivan, M., & Rasmussen, C. (in press). A case study of change in the teaching and learning of Precalculus to Calculus 2: What we're doing with what we have. *Primus.*

Birnbaum, R. (1991). *How colleges work: The cybernetics of academic organization and leadership.* San Francisco: Jossey-Bass.

Carreon, F., DeBacker, S., Kessenich, P., Kubena, A., & LaRose, P. G. (2017). What is old is new again: A systemic approach to the challenges of calculus instruction. *Primus, 27*(4)*.* Available online first http://www.tandfonline.com/doi/full/10.1080/10511970.2017.1315474. DOI 10.1080/10511970.2017.1315474

Elrod, S., & Kezar, A. (2016). *Increasing student success in STEM: A guide to systemic institutional change.* Washington, DC: Association of American Colleges and Universities.

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America (PNAS), 111* (23). Retrieved from www.pnas.org/cgi/doi/10.1073/pnas.1319030111.

Gleason, J. & Cofer, L.D. (2014). Mathematics classroom observation protocol for practices results in undergraduate mathematics classrooms. In T. Fukawa-Connelly, G. Henry, R. (2010). An assessment of STEM faculty involvement in reform of introductory college courses. *Journal of College Science Teaching, 39*, 74–81.

Hayward, C. N., Kogan, M., & Laursen, S. L. (2015). Facilitating instructor adoption of inquiry-based learning in college mathematics. *International Journal of Research in Undergraduate Mathematics Education, 1,* 1-24. Online first: http://dx.doi.org/10.1007/s40753-015-0021-y DOI 10.1007/s40753-015-0021-y

Henry, R. (2010). An assessment of STEM faculty involvement in reform of introductory college courses. *Journal of College Science Teaching, 39*, 74–81.

Kezar, A. (2014). *How colleges change: Understanding, leading, and enacting change.* New York: Routledge.

Laursen, S., Hassi, M. L., Kogan, M., Hunter, A. B., & Weston, T. (2011). *Evaluation of the IBL mathematics project: Student and instructor outcomes of inquiry-based learning in college mathematics.* University of Colorado at Boulder. Retrieved from: http://www.colorado.edu/eer/research/documents/IBLmathReportALL_050211.pdf

Laursen, S. L., Hassi, M.-L., Kogan, M., & Weston, T. J. (2014). Benefits for women and men of inquiry-based learning in college mathematics: A multi-institution study. *Journal for Research in Mathematics Education, 45*(4)*,* 405-418.

Rasmussen, C., & Wawro, M. (2017). Post-calculus research in undergraduate mathematics education. In J. Cai (Ed.), *Compendium for Research in Mathematics Education,* pp. 551-582. Reston, VA: National Council of Teachers of Mathematics.

Rasmussen, C., & Kwon, O. N. (2007). An inquiry-oriented approach to undergraduate mathematics. *Journal of Mathematical Behavior, 26*, 189-194.

Strauss, A. & Corbin, J. (1998). Basics of qualitative research: Techniques and procedures for developing grounded theory (2nd ed.). Thousand Oaks, CA: Sage Publications.

Walter, E. M., Henderson, C. R., Beach, A. L., & Williams, C. T. (2016). Introducing the postsecondary instructional practices survey (PIPS): A concise, interdisciplinary, and easy-to-score survey. *CBE Life Sciences Education*, *15*(4), 1–11. https://doi.org/10.1187/cbe.15-09-0193

Webb, D. C., Stade, E., & Grover, R. (2014). Rousing students' minds in postsecondary mathematics: The undergraduate learning assistant model. *Journal of Mathematics Education at Teachers College, 5*(2), 39-47.

Yin, R. K. (2003). *Case study research: Design and methods, 3rd Ed.* Thousand Oaks, CA: Sage Publications.

Inquiry-based Learning in Lower Division Undergraduate Mathematics Courses as a Recruiting Tool for Future Mathematics Teachers

Janice Rech, University of Nebraska at Omaha, Mathematics, jrech@unomaha.edu
Angie Hodge, Northern Arizona University, Mathematics, angie.hodge@nau.edu
Michael Matthews, University of Nebraska at Omaha, Mathematics, michaelmatthews@unomaha.edu

Abstract

We report how the Research Action Cluster (RAC) on active learning has impacted institutional change at one university in calculus and precalculus, including recruitment efforts for future teachers. We describe how inquiry-based learning (IBL) has been implemented in the calculus sequence over the last five years and a pilot precalclulus program has begun. The IBL format of the courses allow students environments in which they feel comfortable exploring and doing challenging mathematics; an environment in which failure and struggle is not stigmatized. Results show that students think about mathematics in terms of problem solving, making sense, persevering, and where self and peer critiques are the norm. Moreover, as instructors using an IBL format, we found it a powerful framework in which to identify students with a strong capacity for communication and reasoning and thus target our recruiting efforts. We hypothesize that encouraging students to focus on sense making and problem solving, along with providing rich extra-curricular activities and personal recruiting efforts drove our success in recruiting students from IBL classes into the teacher pathway programs.

Keywords: Inquiry-based learning, active learning, teacher recruitment, calculus, precalculus

Introduction

For the past five years, the University of Nebraska at Omaha (UNO) has collaborated with other universities engaged in the Math Teacher Education Partnership (MTE-Partnership) Active Learning Mathematics Research Action Cluster (ALM RAC) to create institutional change in the way teachers learn mathematics at UNO. The group's focus was on the improvement of mathematics instruction in introductory mathematics courses. UNO has collaborated in both defining and implementing the plan for the RAC with a focus on first- and second-semester calculus by implementing inquiry-based learning (IBL) in the courses. Additionally, one section of precalculus implemented IBL. The two main goals of the implementation were 1) to improve learning in the courses and 2) to serve as a recruiting tool for future mathematics teachers.

Description

Transforming Calculus

Two faculty in the mathematics department at UNO were the nucleus for the transformation of calculus I and II. The faculty went through significant training in the use of IBL in the classroom. They recruited two other faculty to utilize this approach in their classrooms. The additional faculty were engaged for a short time, but the two primary faculty members have worked diligently over the past five years on developing activities and problem sets (worksheets) in their IBL calculus classrooms. The long-term goals of these efforts were to significantly increase student learning and to recruit more students into mathematics and mathematics education. Rather than showing facts or a clear, smooth path to a solution, the instructor guides students via well-crafted problems through an adventure in mathematical discovery (Kogan & Laursen, 2014). The United States calculus study (Bressoud, Mesa, & Rasmussen, 2015) suggests that the calculus sequence may be the ideal place to provide future teachers with such learning experiences.

Calculus is often the course that either steers people into STEM majors or out of them depending on their success in the course (Meyer & Marx, 2014). This includes students pursuing mathematics teaching degrees. According to world-class standards for mathematics teachers (Schmidt, Burroughs, & Cogan, 2013), the gold standard for mathematical coursework includes three semesters of university calculus (beginning calculus, calculus, and multivariate calculus). Schmidt, Burroughs, and Cogan discussed the importance of calculus for mathematics teacher preparation. Our teaching in this course impacts a large number of students who have potential in the science, technology, engineering, and mathematics (STEM) fields, including those who already intend to be future mathematics teachers and those who we could recruit into teaching if they are inspired to do so based upon their experiences in the calculus sequence (Mesa & Burn, 2015). Calculus I and Calculus II were targeted as courses for IBL instruction because students interested in STEM fields are enrolled in these courses and most are first-year college students. Many first-year students make decisions regarding their major field of study. Many are not certain of their career goals, but they know they are good at mathematics. This time presents an opportunity to inspire students based upon positive experiences in the calculus sequence. Students who are thus inspired are more likely to switch to education as a possible career.

It is often quoted that "teachers teach as they were taught" (e.g., Hall et al., 2006). Current research reveals that teachers actually teach in the way they preferr to be taught, or the way they believe their students will learn best. (Cox, 2014). For teachers to integrate the mathematical practices of teaching (Cobb et al., 2011), they must have productive experiences first as students.

The use of active learning, which IBL may be categorized as, promotes the mathematical practices of teaching (Common Core State Standards Initiative, 2010). This is a learner-centered method focusing on sense-making activities. Students do more than take notes and write down definitions. Rather, they tackle tasks that require them to engage with one another, to experiment, and to explore the mathematics presented. The role of the instructor is to guide the students in their sense making.

Following the University of Colorado Boulder learning assistant model, the UNO faculty began the use of learning assistants in their respective Calculus II sections. The faculty trained the learning assistants to serve as support personnel for the students throughout the course. The use of a learning assistant is critical in this process, as the calculus students are usually working within groups of three to four students, and it is imperative that some direction and assistance be given at appropriate times. When class sizes are large, the addition of a learning assistant helps to have more hands on deck to help guide students if they are feeling stuck or lost. The learning assistant, like the instructor, does not tell the answers, but rather she/he aids the students by asking appropriate questions and helping them to feel confident in doing the mathematics.

The UNO faculty, in partnership with faculty from the University of Colorado Boulder, created a plethora of activities and worksheets for Calculus I and II classrooms. These activities are now openly available to calculus instructors. These activities include "TACTivities," which are hands-on manipulatives of cards or objects as well as worksheets created for daily classroom work.

Extending the Reach of IBL into Precalculus

Inclusion of the precalculus course in the IBL format was a result of positive experiences of students in the calculus courses. One of those students became a participant in the Noyce Scholarship program. The program was initiated at UNO to support future secondary math teachers (Noyce Scholars) that agree to teach in high-need schools. As part of this program, the Noyce Scholars are required to initiate or be involved in programs and activities throughout the community that promote mathematics education. The impact of IBL instruction in calculus on this Scholar was significant. She came to believe that students can learn best in this environment. When she consulted with a faculty mentor regarding projects for the upcoming year, she suggested implementing IBL in the precalculus course. The faculty member was already using IBL in teaching a History of Mathematics class and elements of IBL in mathematics courses for elementary teachers, but he had no experience teaching a more traditional mathematics course such as calculus or precalculus using this format. Having taught trigonometry twice using a traditional lecture approach and having seen the high D-Fail-Withdraw (DFW) rates that were common at UNO, following national trends (Babaali & Gonzalez, 2015; Brusi, Portnoy, & Toro, 2013), this faculty member was open to change. This faculty member had also seen the significant impact IBL instruction in terms of recruiting future teachers and thought that an IBL precalculus class might be a sensible next step to try. The goals of the pilot study that concluded last year were to implement IBL in the precalculus curriculum and to decrease DFW rates, along with hopefully having an impact in recruiting students into teaching careers.

Homework Room

The inclusion of "homework room" in the IBL format at UNO has proven to be an important component. Faculty and learning assistants staff an open-study room for students one hour before class daily. Students are encouraged to attend and work on homework problems. The format of the study room is much like the classroom. Students work together, while faculty and learning assistants guide them. The faculty and learning assistants do not simply provide a solution. Students are encouraged to find their own solutions. Efforts are made to carefully examine student work to determine the source of the confusion. Through this process, "the light comes on" for students. The faculty role is not simply that of the conveyor of information. Rather, the faculty engages with the student, listens to the explanations and steers them to an understanding of not only the specific homework problem, but an understanding of the underlying concepts.

The Classroom

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 homework. As needed, up four problems were presented to the class (typically 3-4). 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 is a great testimony to the strong support students give to each other and their willingness to work cooperatively. Often, more is learned from the presentations with errors than those that are correct.

After an initial introduction of the day's topic, 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 are typically worksheets that guide the students through specific ideas and concepts, and hands-on manipulatives are used intermittently as well. While students are working together on activities, the instructor and learning assistant circulate around the room listening to students and their exchanges, and give "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. Importantly the IBL 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.

Participation

As an example of how participation was graded, we cite the participation breakdown for the precalculus course. Participation was graded similarly for the calculus sequence. The "active participation" grade was a key element in what made our course different from traditional mathematics classes. It was decided that students would be required to present three times (four if they wanted extra credit) before the end of the semester as part of their participation grade. Homework problems to be presented were chosen because they had important concepts embedded within the problem. These were selected by the instructor and learning assistant prior to class time. Students signed up to present homework problems after their work was checked to make sure that their efforts were at least on the right path, and would lead to a discussion of the topic at hand. Only six students in precalculus failed to complete their three presentations (no one who came to class failed to complete this requirement in the calculus sequence). During class, 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 some of their work. The participation grade was more than just presentations. Students were expected to attend class regularly (and for the calculus sequence attend homework room and other mathematics activities). When in class, students were expected to be working within their groups and asking questions during class presentations.

Methods

The faculty have conducted various research initiatives to measure the success of the IBL teaching in the calculus sequence (including precalculus). An in-depth study of the students over the course of the last few years, including pre-post-surveys on student attitudes about mathematics, persistence data, qualitative data (including math autobiographies), student performance data, student work samples, and data from the writing activity we will describe here. The surveys were given at the beginning of the semester and end of the semester. All other data has been collected on an ongoing basis.

The results demonstrated how student beliefs about teaching and learning mathematics can change by taking one or two courses that employ the active learning method of teaching.

Results

We report the results in several parts. First, we discuss the impact on the IBL calculus on dispositions toward problem solving and mathematical thinking. Second, we report the impact on the IBL precalculus on pass-fail rates. Finally, we talk about impacts of IBL calculus classes on teacher recruitment efforts.

Calculus Results

Each semester students were given a writing activity mid-semester. This writing activity is called a "rose, bud, and thorn" activity. The students are asked to write about one thing they think has blossomed as a result of this course (the rose), one thing that is developing (the bud), and one thing that is still a sticky point (the thorn). The activity has generated data that suggest the active learning calculus is getting students to think about the mathematical practices of teaching as well as getting them to reflect on how they think mathematics best be learned. The following are four representative quotations to help illustrate the results.

Reflecting on mathematics

> This course has opened me up to a new way of learning math. In the past, my math classes really only involved somebody lecturing. I like how in this class we go through more examples/homework and how I

have a group of people to bounce ideas off of. There really is not much to complain about. I believe this class has made me have a new understanding of math. I used to just memorize equations, now I understand how to actually solve those equations.

Making sense of problems and persevering in solving them

I think that the open table work is a rose because it allows us to learn together and share how we learned the material. It helps us to understand a problem in different ways and see new approaches to a problem. A thorn would be the lack of lectures. There are times in class where I feel like all I know is the procedure to solving the problem and not the way. There are times when I feel like I couldn't explain why I solved a problem this way either than the fact that it is the procedure. The bud goes with the rose in that you can grow when you see the approach that other people use to solve the problem.

At first, I was overwhelmed because it had been a long time since I had had Calc I. It was discouraging and very challenging at first. It has gotten better but I still find myself recovering prior knowledge I had forgotten. It is a constant learning process. I am glad I stuck it out because I really do like math. This class is my favorite class because there are several opportunities for growth. I also love the group learning atmosphere. I have gained some good friends through Calc II. It will be interesting to see where I go with math in the future.

Constructing viable arguments and critique the reasoning of others

This course is fantastic for peer-group building and learning experience. It really forces students to interact and discuss topics, which is very refreshing for a math class. Bud: The mixture of professor-led lectures and student-led examples is a great idea, but I felt that the ratio might have been off slightly. I would have preferred fewer presentations, but I'm sure others would have liked even more of them. Summary/Thorn: There really aren't any purely negative things about this class. The content is challenging but there are multiple resources for help provided. The teaching style is different, but the lectures are engaging and there is a massive sharing of ideas occurring at all times. Again, nothing is objectively bad here. Great class!

Pre-Calculus Results

One of the goals of the precalculus IBL class was to improve the pass-fail rate. The results were promising. The DFW rate (28 percent) for the IBL precalculus section taught in fall 2016 was better than the historical average at to 40.8 percent for the historical average since 1995. See the box-and-whisker plot in Figure 1 to see how this course faired compared to 99 other precalculus courses since 1995.

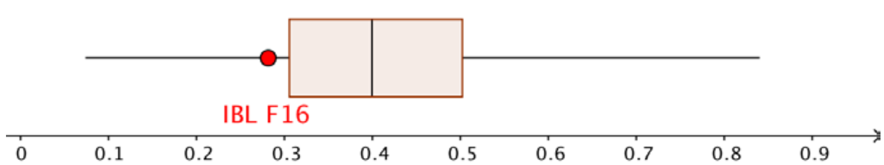


Figure 1. DFW Rates of Math 1340 at UNO from Fall 1995 to Spring 2016.

The successes in both the DFW rates dropping and also the positive feedback from our surveys suggest that there are good things happening in the IBL courses at UNO. In addition, we have found our IBL classes to help us in the recruitment of future mathematics teachers.

Recruiting Future Teachers

The active learning nature of these classrooms allows us to recruit students into mathematics education. Every day, as instructors, we get to hear our students think and watch them work collaboratively with other students. We literally see how our students interact and how they help others in the classroom. This allows us to hand pick students who we think would be good future teachers.

Once we identify students who would potentially make good future teachers, we invite them 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 us on mathematics education research and other projects, and/or d) work as learning assistants in our mathematics courses.

These efforts have been very successful. Almost all of our 30 Noyce interns/scholars have been recruited from IBL classrooms. These students go on to be future mathematics teachers, who will also have experiences being part of an IBL classroom. Many of these students were not originally planning on being teachers initially. Overall, we have seen a marked increase in the number of students who are going into our B.S. in Mathematics with initial teacher certification pathway. The number of students taking this pathway has increased by more than 100 percent from four years ago when the IBL calculus classes started. While we do not believe that all of this increase is due to the IBL calculus classes, much of it does seem to be related. The recruitment is a result of the efforts tied to the "Active-Learning Mathematics" RAC within the MTE-Partnership. A goal was to institutionalize active learning into our calculus sequence, and use these teaching techniques as recruiting tools for future mathematics teachers. Although we have not reached the institutional level of implementation, the successes with students and future teachers have expanded to other courses.

In the precalculus classes, the instructor went in with a goal of recruiting future teachers by identifying students and encouraging them to continue with IBL calculus. The instructor looks for promising students, as is also the case in the calculus sequence. When we say promising, we mean that they seemed to enjoy the mathematics, especially the challenge of working through the harder problems. The students also worked well in their groups and did a good job explaining their reasoning and solutions when talking to the whole class. We feel like these promising students became accustomed and thrived while learning in an IBL format. They may be heavily influenced toward teaching in future classes because of this early IBL experience. We encouraged many of them to take an IBL calculus section in their next class.

In all of our IBL classes, we also invite or require students to participate in various mathematics outreach events such as the High School Math Contest, the UNO Calculus Bee, Cool Math Talks, and various UNO Math Club events (both social and academic). We have had the best success with this recruitment tactic as a requirement of the course. For precalculus, these events were recommended and few students attended these extra mathematics events. For the calculus series, we require three to four outside of class activities, which we feel has had a large impact on our success in recruiting students in the mathematics major/mathematics education major.

Future Plans and Conclusions

The faculty will continue to work on active learning calculus materials for first and second semester calculus, as well as precalculus. The distribution of the materials to other universities throughout the country is ongoing. Data have been collected regarding the effectiveness of IBL in the calculus and the precalculus classrooms. More students are being trained to serve as Learning Assistants. Additional faculty will be recruited to be incorporate IBL into their classrooms. Faculty are analyzing data and writing articles to be submitted to peer reviewed journals.

By daily engaging in mathematics, communicating mathematics, and even arguing about mathematics, the students in active learning calculus have grown to think that active learning, which aligns with the mathematical practices of teaching, is the best 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 calculus classrooms will also teach mathematics in an active manner. As a result, they will be better prepared to teach kids directly incorporating the mathematical practices of teaching. We realize there is still a great deal of work to be done in this research area. We plan to perform a longitudinal study and observe our teachers in their own classrooms to have evidence of their personal teaching styles. In addition to implications for teaching majors, we are also finding lower drop/fail rates in active learning calculus classes, more people switching to math majors after taking an IBL mathematics class, and an increased number of students that volunteer for community outreach events coming from these classes. Hence, there are more areas to explore and we are willing to share our findings and ideas on any areas of which we have collected data.

For More Information

To learn more about inquiry-based learning in calculus, please contact either Dr. Janice Rech at the University of Nebraska at Omaha (jrech@unomaha.edu) or Dr. Angie Hodge at Northern Arizona University (ang.hodge@gmail.com). For more information about inquiry-based learning in precalculus, please contact Dr. Michael Matthews at the University of Nebraska at Omaha (michaelmatthews@unomaha.edu).

References

Babaali, P. & Gonzalez, L. (2015). A quantitative analysis of the relationship between an online homework system and student achievement in pre-calculus. *International Journal of Mathematical Education in Science and Technology. 46*(5), 687-699.

Bressoud, D., Mesa, V., & Rasmussen, C. (2015). *Insights and Recommendations from the MAA National Study of College Calculus.* Retrieved from https://www.maa.org/programs/faculty-and-departments/curriculum-development-resources/national-studies-college-calculus

Brusi, R., Portnoy, A., & Toro, N. (2013). Student engagement and completion in precalculus mega section: Efficiently assisting student engagement and completion with communications and information technology. *Journal of STEM Education: Innovations and Research, 14,* 20-25.

Cobb, P., Stephan, M., McClain, K., & Gravemeijer, K. (2011). Participating in classroom mathematical practices. In *A Journey in Mathematics Education Research* (pp. 117-163). Netherlands: Springer.

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.

Cox, S. (2014). *Perception and influences behind teaching practices: Do teachers teach as they were taught?* Dissertation submitted to Brigham Young University, Paper 5301.

Hall, L. D., Fisher, C., Musanti, S., & Halquist, D. (2006). Professional development in teacher education: What can we learn from PT3? *TechTrends: Linking Research and Practice to Improve Learning, 50*(3), 25-31.

Kogan, M., & Laursen, S. L. (2014). Assessing long-term effects of inquiry-based learning: A case study from college mathematics. *Innovative Higher Education, 39*(3), 183-199.

Mesa, V., & Burn, H. (2015). *The calculus curriculum in the national study of calculus in the USA.* Retrieved from https://deepblue.lib.umich.edu/bitstream/handle/2027.42/113669/Mesa_Burn_Calculus%20Curriculum_National%20Study%20of%20Calculus.pdf?sequence=1&isAllowed=y

Meyer, M., & Marx, S. (2014). Engineering dropouts: A qualitative examination of why undergraduates leave engineering. *Journal of Engineering Education, 103*(4), 525-548.

Miller-Reilly, B. (2007). Three different teaching approaches in pre-calculus bridging mathematics. *International Journal of Mathematical Education in Science and Technology, 38*(7), 891-905.

Building an Active Learning Nucleus: Examining a Case Study

Lauretta Garrett, Tuskegee University, lgarrett@tuskegee.edu
Kelly Bragan Guest, Tuskegee University, kbraganguest@tuskegee.edu
Ana Tameru, Tuskegee University, atameru@tuskegee.edu
Zekeriya Karatas, University of Cincinnati Blue Ash College, zekeriya.karatas@uc.edu

Abstract

HBCUs and other smaller institutions wishing to change practices in mathematics instruction at their institutions can begin with a nucleus of dedicated personnel and initial activities and teaching strategies that will provide experience in active learning instruction for faculty and supportive data to present to key institution stakeholders. In Phase 1 of our pilot program, instructors have introduced active learning tasks and used peer collaboration in precalculus courses. In this report, we describe one case study from this implementation as an example of the learning and adaptation that may occur when faculty incorporate active learning into existing course structures.

Keywords: active learning, institutional change, case study

Introduction

An Active Learning Nucleus

Active learning can positively impact student achievement and attitude (Prince, 2004). Culture change at a small institution where faculty have heavy teaching, research, and service responsibilities can be challenging. It requires those who desire change and are willing to work for it. Change makers require the support and resources necessary for their work. This core of willing workers and supportive resources might be thought of as a nucleus of change. A nucleus "directs all activities that occur within [a] cell and also contains the cell's genetic material, or DNA. The nucleus gives the signal to the cell to grow, divide or make proteins" (www.reference.com). The active learning nucleus can provide a look at the pattern of active learning instruction and provide research data that supports departmental growth. Those who take the first steps in bringing active learning into an institution form the foundation upon which change can be built.

Research questions

We present a case study of a member of an active learning nucleus. This study describes changes in the practice of a faculty member, Dr. Williams, in a mathematics department at a small historically Black college (HBCU) in the southeastern United States. A pseudonym is being used to protect the confidentiality of the faculty member and her students. Our research questions are:

- What challenges arise when mathematics faculty attempt to incorporate active learning into a traditional college precalculus course?
- What emerges in examining one teacher's beginning practices in active learning that might help other institutions to effect change?

Supporting Institutional Change

When mathematics department faculty teach using an active learning paradigm, they provide more opportunities for students to engage in productive mathematical habits of mind and to use reasoning and logic, rather than just rote procedures (Mathematics Teacher Education Partnership [MTE-Partnership], 2014). Examining case studies of such situations can provide data needed to support institutional change. Tracking the process of change from the nuclear beginnings can provide empirical data that correlates with institutional goals. Colleagues learning from members of their own department can see how to more effectively implement active learning. Such collaboration can build a collegial philosophy of learning from each other needed for productive institutional change (MTE-Partnership, 2014).

Networking and Productive Learning Cycles

The three faculty members engaged in the implementation of which this case study is a part began their work with materials provided through the Active Learning Mathematics Research Action Cluster (ALM-RAC) network. They chose the University of Nebraska-Lincoln (UNL) precalculus materials and obtained permission to try three to five activities. After trying these activities, they decided that creating their own materials based upon the ideas they saw in the UNL materials would be more effective for their students. In this way, the networked support from the ALM-RAC provided base-line materials that gave the faculty members experience with active learning and allowed them to study the use of those materials and act to change the implementation. This case study will describe one faculty member's experience with this process.

Description

Methods

Dr. Williams' practice during the 2016-2017 academic year was examined through a semi-structured interview conducted by the lead author at the end of the fall 2016 semester and an observation conducted during the spring 2017 semester. In addition, Dr. Williams described her own choices and implementations in writing, responded to follow-up questions, and collected student survey data about the activities. The purpose of the interview was to determine Dr. Williams' thoughts about the fall implementation and any changes she hoped to make during the spring semester. The observation was conducted during the spring semester to confirm Dr. Williams's understanding of active learning. The observer used the Math Classroom Observation Protocol for Practices (MCOP^2) (Gleason, Livers, & Zelkowski, 2015) and took field notes. The course observed was Precalculus Algebra, and the lesson topic that day was domains and graphs of logarithmic functions. Dr. Williams also provided grades and student learning outcome results for both semesters. Student learning outcomes are learning goals set by the mathematics department as measures of student achievement. The findings reported here focus on interview and observation data, written descriptions of practice, and student surveys.

Findings

The teaching strategies employed by Dr. Williams included pausing during lectures to ask students to continue an example using prior knowledge to engage them in the whole group discussion. She also was able to discover gaps in prior knowledge. She gave them exercises to work on their own in class, allowing students to present work. When students presented work, she allowed the class to ask the presenting student questions before going over the work herself. Her self-described understanding of active learning was as a process in which students "engage . . . through discussion, critical thinking, or other actions, rather than passively receiving information via lecture or similar format."

Active learning implementation fall 2016. Dr. Williams described the challenges she had incorporating active learning into the fall 2016 semester. She said that her students were "needier . . . than usual and ... less capable of problem solving on their own."

> They just – had a harder time getting to think for themselves about things. And so that actually ... kind of rolled into when we were doing the active learning activities. They just seemed like a lot of them just felt lost about how to approach it.

During the fall 2016 semester Dr. Williams implemented two tasks drawn from the UNL precalculus course: a linear functions group activity and a combining transformations group activity. Students were asked to work together in groups to answer six to seven questions during a class period, and they were asked to turn in their work for three of those questions. She covered some of the basics the day before and discussed the activities at the beginning of the next class meeting. During the activity, Dr. Williams walked among the groups and answered questions, trying to keep her answers to questions and hints as brief and open-ended as possible. She emphasized student thinking, encouraging them to see what they could come up with on their own. Rather than answer the question, "Is this right?" she encouraged them to compare their work with another group's work. During the interview, she described her experiences:

> [M]y goal was to just let them go and let them work and make them work through it as best they could together hoping they would help each other out. Many of the groups ended up raising their hands and just saying, "we just have no idea what to do with this" and so I tried to give them hints about, "Well try thinking about it like this." I tried to not just give away any of it and there were some moments when I thought, "I wish I hadn't said this much." Like I made a jump for them they could have made. … [T]he second activity – went about the same way. … Again I felt like they just ... didn't have the tools or couldn't make the jump of trying new things – trying to figure things out on their own. So in both cases that has been the same situation of they tried to work together – ended up feeling stuck – I had to give [loads of] hints.

To address the challenges seen during the first semester, she decided to break the work up into smaller pieces and to spend more time "unpacking what [they] had done." Among the ideas she had for unpacking were "going over what they'd done" and "asking them questions about what their thought process had been." She felt that she should have done more "thinking ahead" about how to use the activities. She said, "I will be more deliberate about what activities I pick and more thoughtful about fitting it in."

At the end of the semester, students evaluated the activities they had done in class. The dominant theme among their responses was that they benefited most from working together with their peers. The reasons that students said they liked working together fell into three main categories: 1) someone else was able to help them with problems they didn't understand, 2) hearing their classmates explain their different thought processes reinforced multiple ways of thinking about a problem, and 3) after explaining their own thought processes to their classmates, they had a stronger understanding of the material.

Active learning implementation spring 2017. During the Spring 2017 semester, Dr. Williams used activities designed to better meet the needs of her students rather than using the UNL materials. In the fall, she had circulated to observe the students' work and found that most groups were not been able to complete the UNL assignment during the class period and had jumped ahead so they could get to the three problems she was requiring them to submit. For Spring, the number of questions in the active learning activity was reduced. Her choice was not based upon the differing spring population of students, but rather on her desire that they complete the assignment in class, have time to think deeply about the assignment, and that she meet the goal of covering all required topics during the semester. She said, "I don't think there is enough total class time in the semester to dedicate more than one class to each of [the active learning activities]." The new activities included one or two warm-up problems and one applied problem (with multiple parts). Students turned in all of their work.

While the activities in the fall were more thorough and the students explored similar questions from more angles, the spring activities were more focused so that most of the students were working on the same questions at any given time. This change promoted more interaction between groups. The two spring active learning activities she tried were an inequalities group activity (graph the solution set of an inequality) and a logarithmic functions group activity (recognize the graph of a logarithmic function and interpret a logarithmic function as the inverse of an exponential function).

After the inequalities group activity, students evaluated the activity they had just completed. Similarly to the end-of-semester evaluations from the fall, students felt that they understood the material better when working with their peers. They enjoyed receiving help and being able to compare answers and methods.

Dr. Williams noted that many of the students needed an extra push to interact with one another. To help with this problem, she required them to submit the name of at least one classmate with whom they had compared their answers. The need for students to be pushed was confirmed during the observed lesson. Students were very quiet, with about half of them talking about mathematics. Although most appeared to be trying to solve the problem, only a handful of students (about three) appeared to persevere in getting help.

The questions in the logarithmic functions activity included the instruction "Give reasons for your answers." To support students who were uncertain about how to give reasons, she reminded them that there wasn't a "right" explanation. She prompted them with encouragements to explain their thinking, such as "If you have an answer, there is something that led you to that answer, and that's what I want to hear about." In the observed lesson, she encouraged them to remember "something [they] thought" and to reason. She worked hard to get a reluctant class to talk to one another. She encouraged student-student interaction and support, suggesting they talk to "someone in this row." Observed prompts included:

"Give a sentence or two about why you think that's the best match."

"Not a specific method we've learned. I just want you to try to figure it out."

"Try to convince yourself."

"Have you found one that you think matches?"

"There was something you thought . . . something solid."

"Talk to the people around you."

"Try to come up with at least one sentence."

"See if anybody else around you had an idea."

"I'm not going to say whether it's right or wrong."

"Try to think of other things you can match up."

Summary. Dr. Williams' work during the observed lesson confirmed that she understood the goals of active learning. Although only two active learning lessons were implemented each semester, she had a chance to try active learning and adjust her way of using active learning. She realized her own tendencies to want to say too much as she tried to help students during the fall 2016 semester. She also learned that students liked working together to get help, hearing explanations, and learning from explaining to each other. She streamlined the implementation for the spring semester. Her questioning supported reasoning and collaboration. She gained experience provoking a reluctant class to participate, think, and problem solve. Following the spring semester, she said in response to additional questions, "I think early and regular active learning experiences will go a long way toward establishing expectations and patterns." Even though her standard teaching practice involved engaging students in classroom discussion, the transition to active learning was challenging for students.

Conclusion

Activities created for the spring semester had fewer questions so that activities could be completed during the time allowed for topics during the semester. This choice was based upon the time it took for students to complete the activities during class. Dr. Williams learned more about what types of activities are needed and what it takes to help students learn via the active learning paradigm. This work provides the MTE-Partnership with insight into the needs and challenges faced by mathematics faculty who incorporate active learning within strict departmental parameters in a traditional culture. Faculty members need to know that active learning is a change in learning paradigm for students and that students and instructors need consistency and time to develop a productive active learning relationship. Faculty members also need to understand the work, types of questions, and consistent effort it will take on their part to help their students through this process. The experience of this faculty member and others will be used to continue to refine and expand the active learning offerings at the institution.

For More Information

Contact Lauretta Garrett at Tuskegee University (lgarrett@tuskegee.edu).

References

Gleason, J., Livers, S., & Zelkowski, J. (2015). Mathematics classroom observation protocol for practices: Descriptors manual. Retrieved from http://jgleason.people.ua.edu/mcop2.html

Mathematics Teacher Education Partnership. (2014). *Guiding principles for secondary mathematics teacher preparation programs*. Retrieved from http://www.aplu.org/projects-and-initiatives/stem-education/SMTI_Library/mte-partnership-guiding-principles-for-secondary-mathematics-teacher-preparation-programs/file

Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education, 93*(3), 223-231.

Opportunities Presented by Mathematics Textbooks for Prospective Teachers to Learn to Use Mathematics in Teaching

Yvonne Lai, University of Nebraska-Lincoln, yvonnexlai@unl.edu
Cody L. Patterson, University of Texas at San Antonio, cody.patterson@utsa.edu

Abstract

Secondary teachers have been documented to find content courses ineffective at developing instructional practices for high school teaching. We examined one potential contributor to this perception: tasks in textbooks for mathematics courses designed for prospective secondary teachers. We analyzed commonly used textbooks for whether and how their tasks situated mathematics in teaching scenarios. We found low percentages of such tasks in chapters addressing functions, expressions, and equations. For comparison, we analyzed a chapter on fractions in a textbook for prospective elementary mathematics teachers, finding that such tasks constituted almost half the available tasks. We find that one way to provide more opportunities for prospective secondary teachers to practice using knowledge in the context of teaching is to take existing tasks, which may be general in scope, and embed specific examples within them. We argue that doing so would increase both the quantity and the quality of opportunities for pre-service teachers to learn to use mathematics in teaching.

Keywords: mathematics content courses, secondary teacher education

Introduction

Teacher education – particularly mathematics coursework within a prospective teacher's preparation program – presents a special opportunity to learn to leverage mathematical knowledge for making teaching decisions. As scholars have argued, mathematical knowledge for teaching is a form of applied mathematics (e.g., Bass, 2005); and this form of knowledge has a greater impact on quality of teaching and opportunities for student learning than "purer" forms of subject matter knowledge (Rockoff, Jacob, Kane, & Straiger, 2011; Baumert et al., 2010).

However, pre-service and in-service secondary teachers have been documented to find content courses ineffective at developing instructional practices for high school teaching. Research suggests two main reasons: the content of undergraduate mathematics seems irrelevant to secondary teaching, and the norms of discourse used in academic mathematics seem inapplicable (e.g., Moreira & David, 2008; Ticknor, 2012; Wasserman et al., 2015). Even if content courses are in fact designed to address content, norms, and skills that are useful for teaching, teachers are unlikely to draw on resources they consider irrelevant. Thus, these findings suggest that improving the status quo involves understanding the opportunities that prospective secondary teachers do have to apply mathematics to teaching in their pre-service work and to what extent these opportunities are authentic to teaching practice.

In this paper, we analyzed opportunities for applying mathematics to teaching in a particular resource: tasks in textbooks for courses designed for prospective secondary teachers. We focused on a particular content cluster within these textbooks: functions, expressions, and equations. We asked: (1) To what extent do tasks apply mathematics to teaching situations? and (2) What is the nature of how tasks situate mathematics in teaching? We anticipate that our findings may inform the work of the MODULE(S)[2] Research Action Cluster of the Mathematics Teacher Education Partnership (MTE-Partnership).

We found that tasks that apply mathematics to teaching situations are relatively rare – so much so that we conducted a comparison analysis of a popular textbook for prospective elementary teachers. We found that not only were tasks applying mathematics to teaching far more common in the elementary content textbook, but also that the tasks differed in nature, and were arguably closer to teaching practice. We report the results of the analysis for textbooks for secondary and elementary levels, and we argue that the contrast in these texts reveals features that are consequential to designing tasks that are authentic to teaching.

Conceptual Framework

We use *tasks* to refer to activities in textbooks designed by the authors for learners to do. Because tasks focus learners' attention on certain aspects of content and on certain ways of processing and reporting information (Doyle, 1983), tasks in textbooks for prospective mathematics teachers have the potential to direct attention to how mathematics can be used – and is useful – in teaching. We interpret tasks as potential *approximations of practice*, "opportunities for novices to engage in practices that are more or less proximal to the practices of a profession" (Grossman et al., 2009, p. 2058). Approximations of practice play the critical role in teacher education of providing opportunities for reflection on professional practices and judgments that may in actual teaching require extemporaneous thinking, as well as "deliberate practice" (Ericsson, 2002) of recurrent work of teaching.

Data

The data for this study are 715 tasks in four textbooks. Three textbooks were designed for use in mathematics courses for prospective secondary teachers and one textbook for prospective elementary teachers. Table 1 summarizes the data.

Table 1
Textbooks Analyzed

For prospective secondary teachers	Chapters analyzed	# Tasks
Usiskin et al. (2002)	Ch. 3 (Functions), Ch. 4 (Eqns.)	198
Bremigan, Bremigan, & Lorch (2011)	Ch. 1 (Functions), Ch. 2, 3, 12 (Eqn. Solving)	270
Sultan & Artzt (2010)	Ch. 3 (Eqns.), Ch. 9 (Functions & Modeling)	129
Conway (2010)	No chapters specifically focusing on functions, expressions, or equations	0
For prospective elementary teachers		
Beckmann (2011)	Ch. 2 (Fractions)	118
Total tasks		715

Selection of textbooks. In their review of capstone courses for prospective secondary mathematics teachers, Cox, Chesler, Beisiegel, Kenney, Newton, and Stone (2013) suggested that the most commonly used textbooks are the four listed in Table 1. Additionally, a search of textbooks published by the Mathematical Association of America, the professional society of mathematicians that focuses on mathematics accessible to undergraduates, found one textbook for secondary content courses, Bremigan, Bremigan, and Lorch (2011). Beckmann's (2011) book was chosen for its high score in number and operation (including treatment of fractions) in the National Council of Teaching Quality's (2008) report *No Common Denominator.* There is no comparable survey of textbooks for prospective secondary mathematics teachers.

Selection of chapters*.* In our analysis of texts for prospective secondary teachers, we selected chapters on functions and equations, since the learning and teaching of these topics have been relatively well-researched (e.g., Knuth et al., 2006; Oehrtman, Carlson, & Thompson, 2008). We reasoned that such topics were more likely to afford tasks that applied mathematics to teaching, as more research has been conducted on these topics with regard to teaching practices, student conceptions, and teacher conceptions. For comparison, we selected the chapter on fractions in Beckmann's text for prospective elementary teachers, since teaching and learning of this topic are similarly well-researched.

Analysis

For each task, we determined whether it explicitly applied mathematics to teaching. We defined a task as *explicitly applying mathematics to teaching* if it explicitly described any contextual feature of teaching. Such features were often signaled by phrases such as "suppose you are teaching..." or "a common student approach is..."; requests for a student-accessible explanation; embedded student work or statement of a teaching goal; or representations typically used at that level of teaching and not used beyond that level of teaching (e.g., algebra tiles for polynomials). We made no evaluation of the authenticity of the teaching situation. Table 2 provides two example tasks.

Table 2

Examples of tasks

Explicitly applies mathematics to teaching	*Does not explicitly apply mathematics to teaching*
"Three students are asked to produce an equation for the line passing through the points (1, 3) and (5, 9/2). The students each produce `different' final answers, namely, $y - 3 = \frac{3}{8}(x - 1), y - \frac{3}{8}x = \frac{21}{8}$, and $8y - 3x = 21$. Are all of these equations correct? Discuss." (Bremigan, Bremigan, & Lorch (2011), Section 2.1.2, #4, p. 38)	"Prove that $Ax + By = C$ and $A'x + B'y = C'$ are equations for the same line if and only if there exists a nonzero real number λ such that $A' = \lambda A, B' = \lambda B$, and $C' = \lambda C$." (Bremigan, Bremigan, & Lorch (2011), Section 2.1.2, #6, p. 38)

Findings

We present two findings: one on the frequency of tasks that explicitly apply mathematics to teaching, and one on the nature of such tasks which may account for the contrast in frequency.

Frequency of Tasks

We found that among texts for prospective secondary teachers, there was a relatively low percentage of tasks that explicitly applied mathematics to teaching, as compared to those that did not. The percentages are summarized in Table 3.

We emphasize that we do not take the stance that tasks that do not explicitly apply mathematics to teaching are less worthwhile than tasks that do. However, given secondary teachers' perception of the irrelevance of content preparation, it behooves the field to examine the nature of tasks that do situate mathematics in teaching.

Table 3

Number of tasks that explicitly apply mathematics to teaching

Textbook	# Tasks	# Explicitly apply math to teaching
Usiskin et al. (2002)	198	3 (1.5%)
Bremigan, Bremigan, & Lorch (2011)	270	23 (8.5%)
Sultan & Artzt (2010)	129	28 (21.7%)
Beckmann (2011)	118	57 (48.3%)

Accounting for Contrast: "Variations on a theme" versus "one and done"

Consider the following three tasks from Beckmann (2011): "Discuss why it can be confusing to show an improper fraction such as 7/3 with pieces of pie or pieces of some other object. What is another way to show the fraction 7/3?"; "Erin says the tick mark [shown in a number line figure in the textbook] should be labeled 2.2. Is Erin right or not? If not, why not, and how can she label the tick mark properly"; "Liam says the tick mark [shown in a figure] should be labeled 1.7. Is Liam right or not? If not, why not, and how can the tickmark be labeled properly?" (p. 57).

These tasks typify opportunities in Beckmann (2011) to situate mathematics in teaching. The tasks ask the teacher to do specific work that arises in teaching: representing particular values on the number line and in other forms, as well as considering the limitations of common representations in the context of a particular example. These tasks are "variations on a theme," and it is easy to imagine adding other tasks in this theme that are authentic to teaching and that highlight distinguishing mathematical characteristics of different examples. In addition, explaining particular examples is an essential part of teaching practice (e.g., Leinhardt, 2001); thus a focus on specific examples may heighten these tasks' value as approximations of practice.

Consider now these two tasks from textbooks for the secondary level: "After doing the previous problem, one of your students asks if it is true that if we have a cubic polynomial with roots *r*, *s*, and *t*, then a polynomial that has roots 1/*r*, 1/*s*, and 1/*t* is just the polynomial with the coefficients reversed. How do you respond? Justify your answer" (Sultan & Artzt, 2011, p. 74); "... For 'ordinary functions' from $\mathbb{R}$ to $\mathbb{R}$ (the sort one studies in a calculus class), what are advantages of having data in tabular form? What are advantages of a graph? Try to think of several advantages for each" (Bremigan, Bremigan, & Lorch, 2010, p. 8).

These tasks contrast with those highlighted in Beckmann (2011) in that they fix a mathematical context, and then address this context in a way that is general in scope, rather than focusing attention on specific examples. These tasks, while not accounting for all tasks that explicitly apply mathematics to teaching in the secondary level textbooks analyzed, do account for many of them. Mathematical specificity/genericity is a salient trait because being either too generic or too specific gives less room for variation – and therefore fewer opportunities for deliberate practice (Ericsson, 2002). These tasks are "one and done."

Conclusion

We analyzed tasks from commonly used textbooks, and found that the nature and of tasks for the secondary level were more often "one and done" than "variations on a theme," and that the frequency of these tasks was low, ranging from 1.5 percent to 21 percent of possible tasks. By contrast, we found that a commonly used textbook for the elementary level featured a high frequency of tasks that applied mathematics to teaching, and that these tasks were "variations on a theme."

Tasks such as those in Beckmann (2011) present authentic mini-cases in which teachers can situate mathematics in teaching. In such tasks, teachers have the potential to develop their capacity for modeling representations to students, to inquire how definitions determine particular representations, and through these variations, how explanations of individual specific fractions or values constitute a "generic" explanation that is powerful beyond the specific example in which it is situated (Mason & Pimm, 1984). "Variations on a theme" account for the high proportions of tasks that apply mathematics to teaching at the elementary level, and they also represent substantive opportunities for teachers to situate content knowledge in authentic cases of teaching.

In teaching, explanations often begin with or include examples that showcase important features of a concept (Leinhardt, 2001), and so overly generic tasks, while having the potential to apply to many situations, also obscure the decision making that may need to be made for particular examples. However, this observation also gives us hope for designing more and better tasks for prospective secondary teachers. One suggestion may be to take the more generic "one and done" problems, identify the work of teaching embedded in the task, and then make that work more contextual. Doing so may well increase the authenticity of tasks as approximations of teaching practice, as well as open opportunities for more deliberate practice.

For More Information

Contact Yvonne Lai, University of Nebraska-Lincoln (yvonnexlai@unl.edu).

References

Bass, H. (2005). Mathematics, mathematicians, and mathematics education. *Bulletin of the American Mathematical Society, 42*(4), 417-430.

Baumert, J., Kunter, M., Blum, W., Brunner, M., Voss, T., Jordan, A., Klusmann, U., Krauss, S., Neubrand, M., & Tsai, Y. (2010). Teachers' mathematical knowledge, cognitive activation in the classroom, and student progress. *American Educational Research Journal, 47*(1), 133–180.

Beckmann, S. (2011). *Mathematics for elementary teachers, numbers and operations, Vol. 1*. Boston, MA: Addison Wesley.

Bremigan, E. G., Bremigan, R. J., & Lorch, J. D. (2011). *Mathematics for secondary school teachers*. Washington, DC: Mathematical Association of America.

Conway, J. B. (2010). *Mathematical connections: A capstone course.* Providence, RI: American Mathematical Society.

Cox, D. C., Chesler, J., Beisiegel, M., Kenney, R., Newton, J., & Stone, J. (2013). The status of capstone courses for pre-service secondary mathematics teachers. *Issues in the Undergraduate Mathematics Preparation of School Teachers,* 4. Retrieved from http://www.k-12prep.math.ttu.edu/journal/4.curriculum/beisiegel01/article.pdf

Doyle, W. (1983). Academic work. *Review of Educational Research, 53*(2), 159-199.

Ericsson, K. A. (2002). Attaining excellence through deliberate practice: Insights from the study of expert performance. In M. Ferrari (Ed.), *The pursuit of excellence in education* (pp. 21–55). Hillsdale, NJ: Erlbaum.

Grossman, P., Compton, C., Igra, D., Ronfeldt, M., Shahan, E., & Williamson, P. W. (2009). Teaching practice: A cross-professional perspective. *Teachers College Record*, 111(9), 2055-2100.

Knuth, E. J., Stephens, A. C., McNeil, N. M., & Alibali, M. W. (2006). Does understanding the equal sign matter? Evidence from solving equations. *Journal for Research in Mathematics Education 37*(4), 297-312.

Leinhardt, G. (2001). Instructional explanations: A commonplace for teaching and location for contrast. In V. Richardson (Ed.), *Handbook on Research on Teaching* (4th ed., pp. 333-357). Washington, DC: American Educational Research Association.

Mason, J., & Pimm, D. (1984). Generic examples: Seeing the general in the particular. *Educational Studies in Mathematics, 15*(3), 277-289.

Moreira, P. C., & David, M. M. (2008). Academic mathematics and mathematical knowledge needed in school teaching practice: Some conflicting elements. *Journal of Mathematics Teacher Education, 11*(1), 23-40.

Oehrtman, M. C., Carlson, M. P., & Thompson, P. W. (2008). Foundational reasoning abilities that promote coherence in students' understandings of function. In M. P. Carlson & C. Rasmussen (Eds.), *Making the connection: Research and practice in undergraduate mathematics* (pp. 150-171). Washington, DC: Mathematical Association of America.

Rockoff, J.E., Jacob, B.A., Kane, T. J., & Staiger, D.O. (2011). Can you recognize an effective teacher when you recruit one? *Education Finance and Policy, 6(*1), 43-74.

Sultan, A., & Artzt, A. F. (2011). *The mathematics that every secondary math teacher needs to know.* New York, NY: Routledge.

Ticknor, C. S. (2012). Situated learning in an abstract algebra classroom. *Educational Studies in Mathematics, 8*1(3), 307-323.

Usiskin, Z., Peressini, A., Marchisotto, E., & Stanley, D. (2003). *Mathematics for high school teachers: An advanced perspective.* Upper Saddle River, NJ: Prentice Hall.

Wasserman, N., Villanueva, M., Mejia-Ramos, J.-P., & Weber, K. (2015). Secondary mathematics teachers' perceptions of real analysis in relation to their teaching practice. *Proceedings of the Conference of Research in Undergraduate Mathematics Education*. Pittsburgh, PA.

PRESENTATION ABSTRACTS

To Be or Not To Be: A Study of Prospective Teachers' Underlying Reasons to Pursue the Teaching Profession Across Two Geographic Areas

Maria L. Fernandez, Florida International University, mfernan@fiu.edu
Cynthia Anhalt, University of Arizona, canhalt@math.arizona.edu

Abstract

This presentation shares findings from diverse student populations at two large universities with secondary mathematics teacher preparation programs. Analysis of data from undergraduate students on the underlying reasons that influence their decisions to pursue completion of their programs and enter the teaching profession or leave the program before completion will be discussed. Findings from surveys and narratives completed by undergraduate students from diverse backgrounds at the two universities at opposing geographic sides of the U.S. will be shared to provide insights from current students and past students in the secondary mathematics teacher preparation programs from both universities. Common themes across the data will be discussed in relation to available literature. Themes can help inform and transform recruitment and advising efforts that are currently happening in programs across our universities and those of other MTE-Partnership institutions. Some themes are closely related to family and peer influences, commitment to education, seeing themselves as mathematics teachers, past mathematics education experiences that become well-remembered events for varying reasons, and altruistic or intrinsic motivations to make positive changes in the teaching profession.

Urban Immersion Field Experiences for Pre-service Teachers from a Non-unban University

Jennifer Whitfield, Texas A&M University, jwhitfld@tamu.edu

Abstract

Texas A&M University is located approximately 90 miles from the nearest urban area and is situated between two non-urban school districts. As such, aggieTEACH pre-service teachers typically fulfill their 120-hour field experience requirement in a non-urban setting. This type of experience does not necessarily mirror the urban-type of setting in which many of these students will teach during their induction years. Preparing teachers to thrive in an urban district requires training for a specialized skill set. aggieTEACH pre-service teachers need the opportunity for high-impact learning by interacting with diverse groups of students from urban areas. This includes working with students from different cultural, ethnic, and socioeconomic backgrounds and learning how to successfully educate these students holistically. Preparing pre-service teachers to meet the diverse learning needs of students and use culturally relevant teaching strategies, aggieTEACH partnered with Dallas ISD to design an urban immersion field experience. In addition to 40 hours of classroom experience, pre-service teachers in the program visited and toured community resources, participated in a Public Transportation Scavenger Hunt, and experienced life in an urban setting. The goal of this project was to give aggieTEACH students a high-impact learning opportunity in urban schools by working side-by-side with highly effective STEM teachers and exposing them to the successes and challenges of teaching students who live in urban areas.

Beginning with the End in Mind: Embedding Co-Planning & Co-Teaching Throughout Secondary Mathematics Education

Charity Cayton, East Carolina University, caytonc@ecu.edu
Maureen Grady, East Carolina University, gradym@ecu.edu
Renea Baker, Pitt County Schools, North Carolina, bakerr@pitt.k12.nc.us

Abstract

In 2012, East Carolina University joined the Mathematics Teacher Education Partnership (MTE-Partnership). Joining the MTE-Partnership occurred at a very opportune time for our high school mathematics education program. Our program had not been revised since the late 1990s, and the adoption of the Common Core State Standards for Mathematics (2010), combined with publication of the Mathematics Education of Teachers II (2012), amplified the need for program revisions to meet the growing demands expected of beginning high school math teachers. Also, in 2013, our program piloted co-planning and co-teaching. Each of these elements informed the transformation of our program to prepare high school mathematics teachers. We have remained active participants in the MTE-Partnership and implemented successive Plan-Do-Study-Act cycles to provide data to the partnership and inform program area decisions. As a result, co-planning and co-teaching are embedded, beginning in our junior methods course through the senior internship one and two semesters. This process has solidified existing relationships in our mathematics teaching community and involved all stakeholders (e.g., clinical teachers, teacher candidates, university faculty, and the Office of Clinical Experiences at our university) in better preparing our high school mathematics education graduates for the realities of teaching. We will discuss how we have embedded co-planning and co-teaching into our methods courses and clinical experiences. We will also share data collected and lessons learned after three years of implementation.

References

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.

Conference Board of the Mathematical Sciences. (2012). *The mathematical education of teachers II*. Providence, RI and Washington, DC: American Mathematical Society and Mathematical Association of America.

How Interns and Mentors are Using Co-Planning in Clinical Experiences

Maureen Grady, East Carolina University, gradym@ecu.edu
Charity Cayton, East Carolina University, caytonc@ecu.edu
Renea Baker, Pitt County Schools, North Carolina, bakerr@pitt.k12.nc.us

Abstract

This research report describes an ongoing study of co-planning in the clinical experiences of preservice secondary mathematics teachers. We are in our second year of collecting data about co-planning from our interns, mentors, and university supervisors. All of the interns are in co-teaching settings and all of the participants in the study have received training in both co-teaching and co-planning. Interns and mentors are providing feedback about their use of co-planning strategies and about their perceptions of the effectiveness of co-planning at the beginning, end, and throughout the clinical experience. Interns are including reflections about co-planning in their weekly journals and each intern/mentor pair is recording a co-planning session. University supervisors are using both the Co-Teaching Observation Protocol and the MCOP^2 as tools to record the classroom results of co-planning. In this session, we will share the instruments that we are using for data collection and some preliminary results from our study about the use of and the perceived usefulness of co-planning with secondary mathematics interns.

Transforming Internship Thinking: Using Improvement Science to Enhance Co-Teaching for Student Teaching

Pier A. Junor Clarke, Georgia State University, pjunor@gsu.edu
Ruthmae Sears, University of South Florida, ruthmaesears@usf.edu

Abstract

At an urban, southeastern university, a mathematics teacher educator continues to explore a co-teaching-for-student-teaching (CT4ST) model, which is designed to ultimately improve the outcomes of the clinical experiences of both the cooperating teachers and the pre-service secondary school mathematics (PSSM) teachers. Incorporating researched-based ideas of co-plan and co-teach with the Plan-Do-Study-Act (PDSA) cycles (Bacharach, et al., 2010; Sears, et al., 2017) frames the CT4ST model into three phases during the preparation of PSSM teachers. These phases are aligned throughout the three-semester teacher preparation program to build working relationships, to understand, and to implement the standards of mathematical practices; learn and implement co-planning and co-teaching approaches; and enhance analyses of classroom assessments as the plans to improve PSSM teachers' pedagogy are revisited. The presentation will include one iteration of the CT4ST model and next steps to a structured process for continuous action in enhancing our secondary mathematics teacher education program.

References

Bacharach, N., Heck, T.W., & Dahlberg, K. (2010). Changing the face of student teaching through co-teaching. *Action in Teacher Education 32*(1), 3–14.

Sears, R., Brosnan, P., Gainsburg, J., Oloff-Lewis, J., Stone, J., Spencer, C., Riggs, L., Biagetti, S., Cayton, C. Grady, M., Junor Clarke, P., & Andreason, J. (2017). Using improvement science to transform internship experiences through co-teaching strategies. In L. West and M. Boston (Eds.), *Annual Publication of Mathematics Education* (pp. 265-274). Reston, VA: National Council of Teachers of Mathematics.

Closing Remarks

The Promises of Deconstructing and Disrupting for Critical Transformations

Nicole M. Joseph, Vanderbilt University, nicole.m.joseph@vanderbilt.edu

I want to thank the planning team for inviting me to participate in this conversation. I am going to talk about the wows, the wonders, and what I have learned in the last few days here. Some of the wows are the vision of the MTE-Partnership leadership, which is to bring together and develop a networked improved community and to transform secondary math teacher education. Another wow is the creation of these RACs that seek to identify and address particular issues related to teach you all specific goals and objectives. And lastly the incredible dedication and hard work of you all, in doing this work and doing it well. I did get to spend time in all of the RACs, and I am just blown away by the commitment to the work. Thank you.

I only have one wonder. Three positives, one wonder. I wonder if the MTE-Partnership will be bold and brave to move to a deeper and critical stance of transformation for secondary math teacher education by using its power and privilege as a collective identity to deconstruct and disrupt the hegemony of mathematics. I went and looked for the guiding principles that we can actually hang our hat on to do this work, namely the one that talks about the sense of justice: "The teacher preparation program fosters a sense of agency in its teacher candidates so that through their actions, behaviors, and advocacy, candidates demonstrate a dedication to equitable pedagogy that promotes democratic principles by holding high expectations for all students, while recognizing and honoring their diversity" (MTE-Partnership Guiding Principle 6-C, 2014). One of the things that I was thinking that might be a possibility or a possible exercise is could we situate this particular guiding principle within the context of our new AMTE Standards, specifically the ones talking about social context in mathematics teaching and learning, and even more specifically, section 4.4, which says "understand power and privilege in the history of mathematics education." For those folks that do not know what the word hegemony means, it comes out of Marxist philosophy and tradition. Cultural hegemony is the domination of a culturally diverse society by the ruling class, I'd say whites, who manipulate the culture of that society, the beliefs, explanations, perceptions, values, so that their imposed dominant worldview becomes the norm. The universally validated dominant ideology that justifies the social, political, and economic status quo as just natural, perpetual and beneficial for everyone, rather than as artificial social constructs that benefit only the dominant culture. I want you to look introspectively and think about this question: Can you see the hegemony in math teacher education?

I want you to think about who made the decision, for example, a long time ago, about the scope and sequence of math courses? Algebra, Geometry, Algebra II, Pre-Calculus. Who decided that? Who made the decision about the type of math we need to learn? Why, in the face of 30 years of empirical research about the negative consequences of tracking, have schools still tracked in mathematics? It is benefiting someone. It is a part of a norm, right? And who decided that the GRE, ACT, or any other standardized assessment, that we often need to take for advancement, to get into programs, that those are the only legitimate measures of knowledge? Think about these things.

Why do we need an attempt to be bold? Why do we need you guys to be bold? I want to do an illustration and read a quick vignette in my book that I think really demonstrates hegemony in mathematics. This is the introduction of my book that I shared with you yesterday, "Interrogating Whiteness." There is a picture that is titled "The Defaced Page in the Book: Black *Mathematicians* and Their Work." Has anybody heard of that book? A colleague who was an African-American faculty member in STEM, he's a mathematician in fact, came to my office to show me something he found in a book that he had checked out from the institution's library. The sentiments reflect widely held assumptions that are rooted in the belief that mathematics, like other STEM disciplines, is a white institutional space. In this book, "Black Mathematicians and Their Work," are the contributions and photos of black female and male math faculty who hold a doctorate in pure mathematics or engineering or other STEM areas. Eleven of the photos have been defaced with comments such as "one-half white" (see Figure 1).

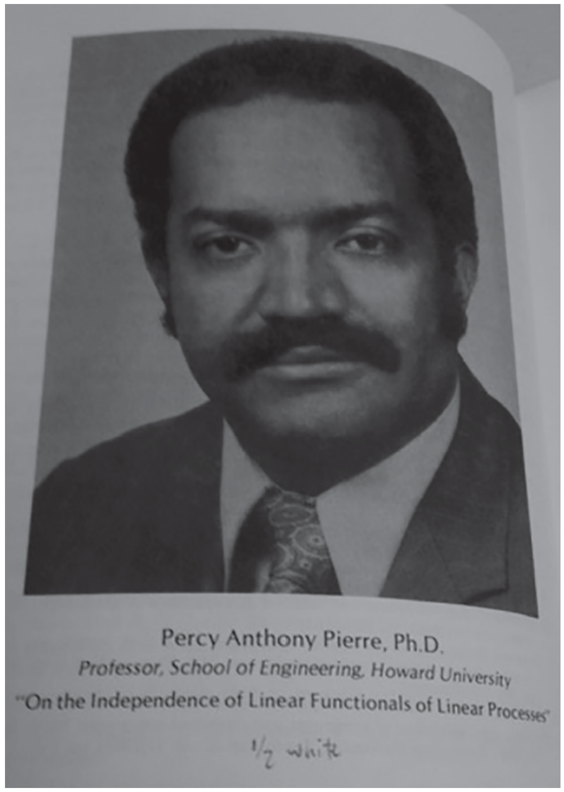


Figure 1. Page from *Black Mathematicians and Their Work.*

All 11 of those pages were defaced in that same way. I guess the writer of the defaced message wanted us to know that for a black person to hold a Ph.D. in engineering, he or she has be at least half white, right? Because achievements like these do not belong to blacks, but are also not typical, not normal, right? For black people. I looked at my colleague with despair and said, "This is one reason why our book is needed."

The other thing that I want you to think about is that I created something called the STEM System (see Figure 2), which is why this is relevant to the MTE-Partnership. The bottom circle says STEM System in U.S. Education, white faculty in STEM departments, so that's our white faculty in STEM education departments, secondary in particular, like most of us. And then white future secondary STEM teachers. That's our audience, right? Those are the people that we teach. So what happens is when you have students that go into these STEM departments, most of them have to have an undergraduate degree in mathematics. You can see that all students are influenced by white faculty focused only on content that's universal and culture-free even though certain students may feel or think differently based on their own lived experiences.

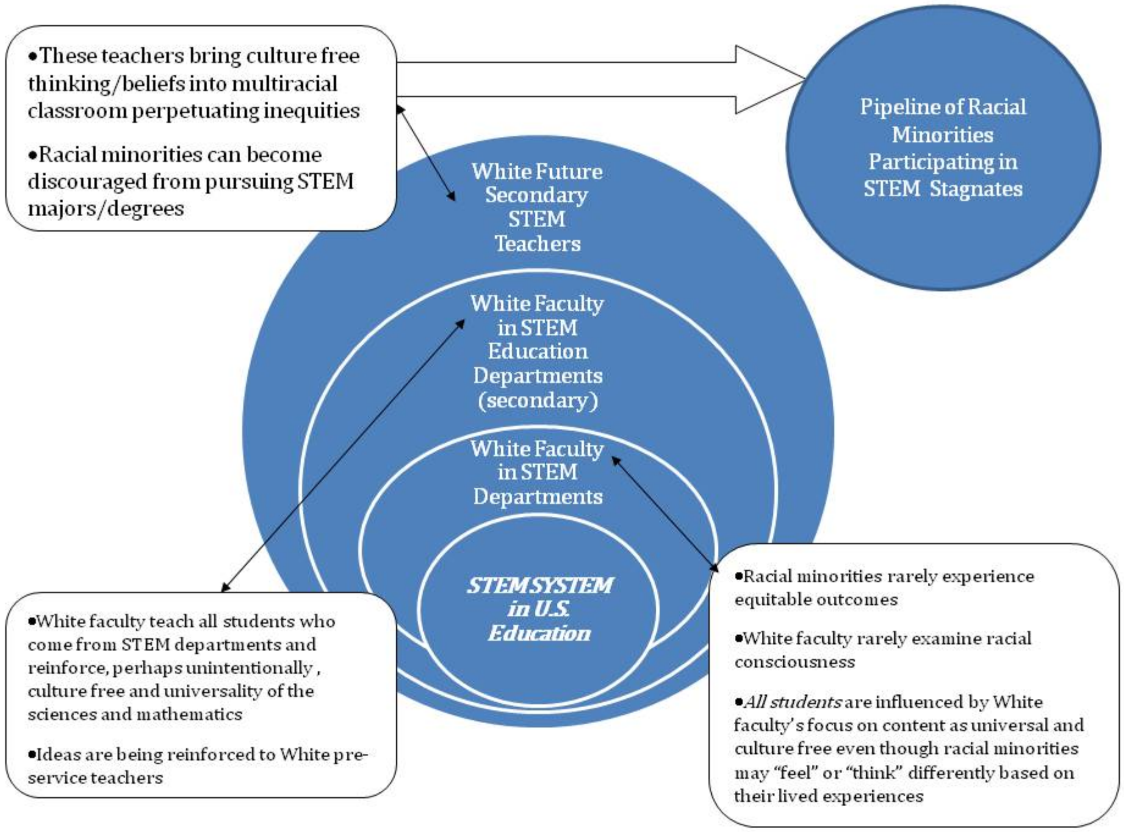


Figure 2. U.S. STEM education system.

Just to show you a pathway, we've got most people getting their degrees, and then they come into education. They come to see us, right? So white faculty teach all students who come from STEM departments and reinforce culture-free universal science, etc. Then we are teaching our teachers and then they go out and get their own class. So, these teachers perpetuate inequalities, unless disrupted. And then what happens? A pipeline of racialized minorities perpetuates and is stagnated, essentially. This is just to sort of provide a frame for us to think about those questions.

Why are racialized minorities not interested in teaching mathematics? This is just something for us to think about, why math is not something that racialized minority students want to do. I have learned that this group has a lot of power, thinking about a hundred institutions, thinking about all of its collaborations and partnerships that have been built across this country. You have a lot of power and privilege, I think, to make a very significant contribution that takes a critical approach to the complex problem of recruiting and retention-building, those two twin aims, right? I have also learned that taking this critical approach can promote catalytic promise in disrupting the myth of mathematics as a white institutional space and has the potential to, for example, improve the perceptions of marginalized students who do not see mathematics as part of their identities.

Promote catalytic climates in disrupting the myth, because it is a myth that mathematics is a white space. But, that culture has been sort of reified through society, through our programs, etc., and have the potential to, for example, improve the perspectives of marginalized students who do not see themselves, or do not see mathematics as part of their identity. And finally, we were kind of throwing around this idea in the PR^2 group, we really need to start a national movement to reclaim teaching as a respected profession. Because of the power and the reach and the leverage that this group has doing something like that could really help raise and elevate the wonderful profession that we all do. Here is a start. Here's a hashtag: #mathteachingforchange. You can use that if you want to do it.

I'm thinking that just like how Black Lives Matters sort of started organically and socially and then it grew, we could do it for math teaching. Find testimonials of those great math teachers that you know are fighting every day, reaching their kids, doing everything that they can to provide excellent teaching to all kids. We can elevate teaching as a transformative practice to change and to perhaps open it up for the type of students that you say that you want to get. So again, I thank you, and I hope that this is something that you all would be willing to think about more deeply.

Taking a Closer Look at How We Communicate: Are We Utilizing the Experts in the Room?

Josh Males, Lincoln Public Schools (Nebraska), jmales@lps.org

I was a high school math teacher for 15 years, and now for the past two years, I've transitioned to a district office position. I've gone to the "dark side." This last year, I have specifically been serving as the K-12 curriculum specialist, which means that I've had to work with groups of people that I have only interacted with in small ways. However, now I get to work with them and dig into some stuff with people that I haven't had to before. Two of the groups that I work with are principals across the district, and then also the special education department. As for the principals, I attend meetings for both elementary and secondary principals. The secondary principal meetings are a very comfortable environment for me. My adult life has been working in high schools, the principals speak my language, and I speak theirs. I don't have to think much when I need to communicate with them. We just understand each other most of the time. (Well, I'd like to think we understand each other most of the time.) It's not always easy, but we at least have a general idea of what the other person is attempting to say.

This year, I have started going to elementary principal meetings. These meetings have a completely different group of people than I've had to work with in the past. There are 40 principals in the room, most of them former elementary teachers. Little things like my slides are "not colorful enough" get in the way of my communication with them. My high school math teacher personality is different from anyone else in the room. So, I have had to consciously think about how I say things and what is being communicated back to me. It is more complicated when we are communicating with each other and working together than when I am working with the secondary principals. I have been learning how this group of professionals works and communicates this year. It has required help from some colleagues that speak the language, and they have helped me make the transition.

The other group that I have started to work with is the special education administrators. The math curriculum team and the special education team have been making a conscious effort to work together. I feel like our two departments have been ships passing in the night, and our teachers have been feeling the disconnect. I know as a classroom teacher, it was a point of conflict. If you want to get two groups of people in a room together and have an awkward meeting, bring together special education administrators and some math teachers that think we know everything. We just speak different languages and have a different outlook on most topics. It took us a couple of meetings of just talking around the same thing for 45 minutes before finally realizing we were saying the same things and agreeing, but just completely using different language. We were just not communicating very well.

On Sunday, when Jennifer was talking about how groups of people work differently, it hit home for me. As I was listening to her, I started thinking about this meeting (my second MTE-Partnership conference), thinking about the different groups of people that are here. We have mathematicians, mathematics teacher educators, and K-12 mathematics educators. Within each of those groups, people certainly don't work the same and don't speak the same way, but each of us works with a group of professionals that all have "grown up" in a culture that has shaped us to communicate within our community in a certain way. These "home cultures" that we come from create a challenge in a group like this as we cross bridges and work together, but I believe these are the different communities that have to work together to enact change.

I want to thank the leadership of the MTE-Partnership for consciously bringing this group of people together because, as Nicole said, it creates a very powerful network of people that can legitimately make some change and do some damage to the native culture that surrounds mathematics.

One of my wonderings is: Are we truly thinking about how we are working together and how we are communicating with each other when our different communities come together, or, are we keeping to ourselves? The math department is doing these things over here, and the math educators are doing those things over there. How are we bringing those different groups together? I think there are certainly some spaces where we are working together, but I'm just wondering are there more places and can we work together more as we are working to improve mathematics education?

Nicole Joseph brought up that education's goal is a cultural reproduction, which I think this is what education does right now. But I think that this group of people in this room has the power to start changing that culture around mathematics and breaking the cycle of what culture is being reproduced.

Another of my wonderings is: Are we bringing the expertise that is out here in this room to bear on the problems that we're trying to solve? We have different RACs. It seems like we are creating curriculum to solve problems or to be the change agent that we need. We know from history that curriculum alone doesn't solve our problems, and I was happy to hear about professional development discussed. How do we bring instructors and professors along with the big changes that are being proposed? I think professional learning is new for math departments at the university level. I'm wondering: Are we consciously bringing in curriculum experts to be a part of the curriculum development? Are we bringing in those people that have thought about teacher change and have worked on professional development? Are the experts in these different fields a part of the conversation as we are working on moving from the small group of people that are excited and wanting to make the changes in the way things are working and expanding the scale of this work? Are we bringing in those experts that have done some of that work in the K-12 world for a long time, and been through those struggles and then learned from those struggles, just to get that perspective and talk about what works and what doesn't work?

As we are working toward making lasting changes, we have to think about how we all work together. We need to bring in experts that have already done similar work to help guide our own work as we start to expand into other fields, and we need to recognize that we are no longer experts. As you invite experts in from a different community, take the time to think about the different ways we communicate with each other, just like I had to learn how to talk to elementary principals and special education administrators. We do things differently, but we all have the same goals, and we want to get to the same place. We need to make an effort to work together. Being aware of the way that we are communicating and forcing ourselves to communicate in a new way is challenging. I'm excited and energized by what is possible with this group of people and what is getting accomplished by the RACs. I feel like this is one of the first times that I am a part of a group where I think actual large-scale change is a possibility. I've heard about change that got started and fizzled out, I've seen pockets of people doing good things, but a systemwide network like this certainly has a lot of power and potential. I hope that we take advantage of that and think about who the experts are in the room and make use of those people.

On Sunday, our Nebraska team was talking about our local setting and thinking how we bring this back to Nebraska. It's one thing to have a big university and a large school district be a part of this partnership. However, as someone that is in a school district that doesn't just hire from the University of Nebraska-Lincoln, we need all the local universities and colleges to be a part of this change effort. We need all the school districts in the area to be headed in the same direction so that when students leave those university methods courses, they are going to a school district that supports the work that they were inspired to do. It has to be a larger community discussion within our communities and within our local region as well. I want to put this out there as something to consider:

Do you have a common vision in your local setting? And if not, how do we get there and make that common vision across communities and partners?

As we think about reaching out to those in our region, we have to consider how we communicate with each other. We are all aware of the fact that it is very easy to come off condescending and preachy, so how do you bring others along on the journey? The team from Nebraska that is here, we are only a small portion of the mathematics community in Nebraska. How do we bring those in our local communities and our state as a whole into these conversations in a way that we are listening to each other and having true conversations?

As a public school administrator, I have the opportunity to deal with local politics. You won't be surprised to know that there are parents out there that have very strong views about what school mathematics is supposed to look like and what should be happening in their child's classroom. These concerns typically come from parents wanting what they think is best for their child. There are instances where the pushback I get is about preparing our students for college. The argument is that our students are going to go into a college math class, so they have to know how to operate in that setting. The question now is: What does a college math class look like now, and what are the expectations of the college mathematics instructor? We have to work together to explain to the public what changes are taking place, why the changes are needed, and that we all agree that these are needed changes to mathematics education.

I believe that for these cultural changes to happen systematically, we must work together to communicate to the public our expectations for what mathematics is and how this impacts what students learn in mathematics classrooms. If the whole mathematics community is not on the same page and working together, then this all falls flat. I hope that we all think about how we are communicating with each other and make use of all of the expertise in both this room and the larger mathematics education community as a whole, mathematicians, mathematics teacher educators, and K-12 mathematics educators.

Reflections on the Partnership

Ed Dickey, University of South Carolina, ed.dickey@sc.edu

Figure 1. Opening slide of presentation.

Gary Martin has set a high bar for me with the video he put together [referring to a friendly spoof video of Ed Dickey]. Thank you, Gary! Nicole Joseph and Josh Males have also set a high bar for me to follow with their interesting insights. Nicole, with this being her first meeting, brings a new perspective and offers challenges, and Josh has been with us before, but he brings the perspective of a school-based person, and so I'm here to provide some personal reflections from my perspective as a member and higher education partner. I've been involved with the partnership since the beginning. I was not part of the original planners who envisioned this work, but I was involved at the early stages, so I'm going to review some of the places that we've been, and in some cases, it will overlap some of what Howard Gobstein did at the opening. And then I'll talk a little bit about where I think we are and also where we might be going, addressing the challenges Nicole Joseph has outlined and some of the directions Josh Males has suggested. The good news is I will finish quickly, and we will get on with other matters.

Where we've been: I want to remind you that we really started out of the Science and Mathematics Teacher Imperative (SMTI), and I really applaud the inclusion of the word imperative. Unlike our principles that might be ignored or may not always guide, imperatives are things we must do, so I applaud APLU in response to President Obama's recognition that we needed 100,000 new math and science teachers, that it is imperative that we recruit new teachers. I thought it was very forceful. As an example, I first met Howard when he came to my campus, and my provost and dean said "go see this guy, because this is important. It involves APLU, and we need to pay attention to them." Our provost and dean pay attention to that organization, and it had clout. I was impressed by Howard's passion for this initiative, so I began to attend the SMTI conferences. Gary Martin and Marilyn Strutchens were also attending these, and they had the insight that mathematics has its own unique needs. So they pushed the issue of a Mathematics Teacher Education Partnership (MTE-Partnership), announced it after the Cincinnati SMTI meeting, where I think some of this coalesced, and then in 2011, late 2011, they announced the partnership to the community of mathematics teacher educators. Applications went out in 2012 with the intention of building a consensus on guiding principles, a collaborative research agenda, and then working to transform programs. These were all the early visions from the outset of the program.

As Howard Gobstein pointed out this weekend, the first MTE-Partnership conference was in 2012 and developed the guiding principles. I want to point out that not only were the *Guiding Principles* reviewed as a draft and discussed extensively, but at the end of the conference, data was gathered and the membership, the hundreds of people who attended that first conference, voted on which priorities were going to guide our work. And out of those priorities, the working groups, one on common vision, one on mentor teachers, one on mathematical knowledge, and one on recruitment and retention, emerged. That's not to say that those were the only things that were in the guiding principles, but it was part of a democratic, research-based process to establish our priorities. And at the same time, right after the first conference in Atlanta, the attention to use improvement science as a possible methodological means of achieving our goals was offered and accepted by the planning group.

As Howard Gobstein mentioned, some of us went to NIC (Networked Improvement Community) training with Carnegie and got involved in learning how to use this methodology. White papers were commissioned, and resources were provided to write the white papers. At the second conference (St. Louis in 2013), which I call the "50 Hours Conference," where in 50 hours -- and by the way, this has been the "44 Hour Conference" if we end on time -- but in 50 hours in St. Louis, we did a "*pivot to action*," which was I think the term we came up with as our theme. The Research Action Clusters (RACs) were formed as an outcome of that conference and once again a democratic process, this time using colored sticky dots as a voting mechanism, was used to establish the actual RACs. Participants went around the room reading posters with each RAC's prospectus and used color-coded dots to indicate first, second, and third priorities. From these votes, the first set of RACs emerged, and after the conference, we applied to join those RACs. We were generously supported by the Helmsley Foundation to get the work done.

The third conference (in 2014), which was in Milwaukee, had the RAC work in full swing. I would call our next stage "*growing capacity*." This is what we've been doing since that time. The Fullerton conference (in 2015) was infused with new energy from a huge group of California State University system institutions who also brought resources. California had support from the Bechtel Corporation and other groups, as well as the leadership and commitment of Joan Bissell, who is a force of nature who can get things done, so it was a wonderful infusion of energy and resources to help us grow our capacity for improvement and program transformation. The RAC were supported by funding, and results were coming forward. The second Atlanta meeting (in 2016) introduced new directions tied to equity and a more direct focus on transformation. I think another huge achievement was the Proceedings, so kudos to Bob Ronau, Brian Lawler, and Margaret Mohr-Schroeder, who took on the work and now provided us with an even higher level of academic recognition. And here we are at the sixth conference in New Orleans (in 2017).

I do want to point out and do so in all sincerity (despite the humorous video shown at the outset) that I've introduced Gary Martin as the hardest-working man in mathematics education, and I say that in part because my favorite South Carolinian is James Brown, known as the hardest-working man in show business. And while Gary Martin doesn't dance like James Brown, though I tried to help him do that [referring to the video of Gary dancing to the University of South Carolina Gamecock at the AMTE 2016 annual conference opening session], he is - -and I have to give him a huge amount of credit for being -- the intellectual tour de force that brought the MTE-Partnership into being and shepherded its work over the years.

So in all stages of our work, and in each piece of what we do, Gary Martin's leadership and commitment serves to move us forward. It just brought me to tears today when I opened up my Facebook feed this morning to find that today is Gary and my sixth friendversary. [Ed and Gary embrace in a bro hug.]

I think I can go on. So Gary Martin, thank you for all you've done, and I would be remiss if I didn't point out that Howard is equally involved, and it's a wonderful example of shared leadership. I once co-directed an NSF project where you're not allowed to co-direct. You're allowed one PI, and we argued that we could have two, well that was early in my career and I learned better -- you can't co-do anything. There's got to be one person in charge. Well, here's the counter-example: Gary Martin and Howard Gobstein truly have modeled collaborative leadership. They bring different dimensions, and I think we really benefit from the two perspectives, and I've changed my own view that you can't have two co-leaders. You actually can, and they've done it very well.

Figure 2. Gary Martin, MTE-Partnership Co-Director, throughout his career.

Figure 3. Ed Dickey and Gary Martin Facebook Friendversary. Gary with Randy Philipp, Christine Thomas, and Marilyn Strutchens.

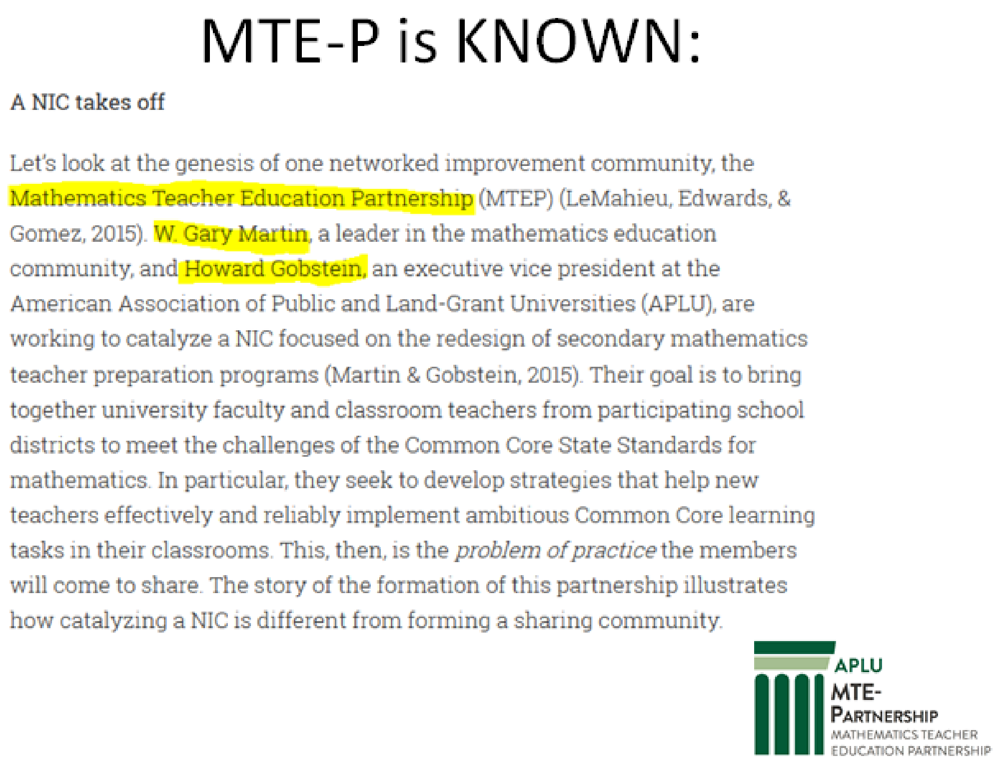
Figure 4. Howard Gobstein, MTE-Partnership Co-Director, throughout his career.

I wasn't sure if Gary Martin or Howard Gobstein would be kind enough to thank Mary Leskosky for everything she has done and is still doing to support this conference and the partnership. I do know, having been involved with this with Katherine Hazelrigg who held Mary's position at the outset of the MTE-Partnership, that it's a huge amount of work. There's Mary (see Figure 5), not sitting down at her desk but out working, helping as always. I had to go find her and she and Margaret Mohr-Schroeder were together. So--we've got to thank Margaret too, but I do want to acknowledge that this leadership team is a triumvirate of people who get things done.

Figure 5. Mary Leskosky with Margaret Mohr-Schroeder.

So, where are we? I think we are a solid mature partnership. We're national; we're diverse in the many definitions of diverse. We're respected and impactful. Our guiding principles -- I don't hear discussion about changing them -- I think they're very sound, and I encourage you to go back and read them. I commend Nicole Joseph, who actually did read them, and picked up on one that is extremely important. But I think the principles are sound, and they should continue to guide us, and I'll remind you that we aren't doing everything listed in the principles-- Nicole Joseph reminded us of this, but I think overall the principles are comprehensive, very sound, and in good shape.

We have a RAC structure. We even have subgroups of RACs, and we have had situations where we recognized that some RACs might not be needed allowing for a "sunset-ing" of a RAC. We now have five very well-established RACs with the potential of two emerging, new ones. And our partnership is well known. Jennifer Lin Russell talked about our place. If you haven't read the *Kappan* article she mentioned "The right network for the right problem" [http://www.kappanonline.org/right-network-right-problem/], you should read it. I saw it come up in different sessions. People had gone and found this article that mentions our organization, and it shines a very positive light on our work. The *Kappan* is not a refereed journal but it is an impactful journal that is widely read and respected, and we are front and center along with the Math Forum, which is also a network of a different type.


MTE-P is KNOWN:

A NIC takes off

Let's look at the genesis of one networked improvement community, the Mathematics Teacher Education Partnership (MTEP) (LeMahieu, Edwards, & Gomez, 2015). W. Gary Martin, a leader in the mathematics education community, and Howard Gobstein, an executive vice president at the American Association of Public and Land-Grant Universities (APLU), are working to catalyze a NIC focused on the redesign of secondary mathematics teacher preparation programs (Martin & Gobstein, 2015). Their goal is to bring together university faculty and classroom teachers from participating school districts to meet the challenges of the Common Core State Standards for mathematics. In particular, they seek to develop strategies that help new teachers effectively and reliably implement ambitious Common Core learning tasks in their classrooms. This, then, is the *problem of practice* the members will come to share. The story of the formation of this partnership illustrates how catalyzing a NIC is different from forming a sharing community.

Figure 6. Excerpt from *Kappan* article.

But we're there and there's specific mention of why we're there and who we are with examples of our work. So this is indeed national and very positive recognition. I participate in different groups. There's huge interest nationally in the efficacy of the NIC approach. And often this organization is pointed to as: "here's a place that's doing it and doing it right." And I think you experience that whether you are new to our partnership or are a veteran.

We are referenced in the AMTE Standards (2017) and this diagram has shown up in various different sessions throughout this conference, and that's straight out of the standards:

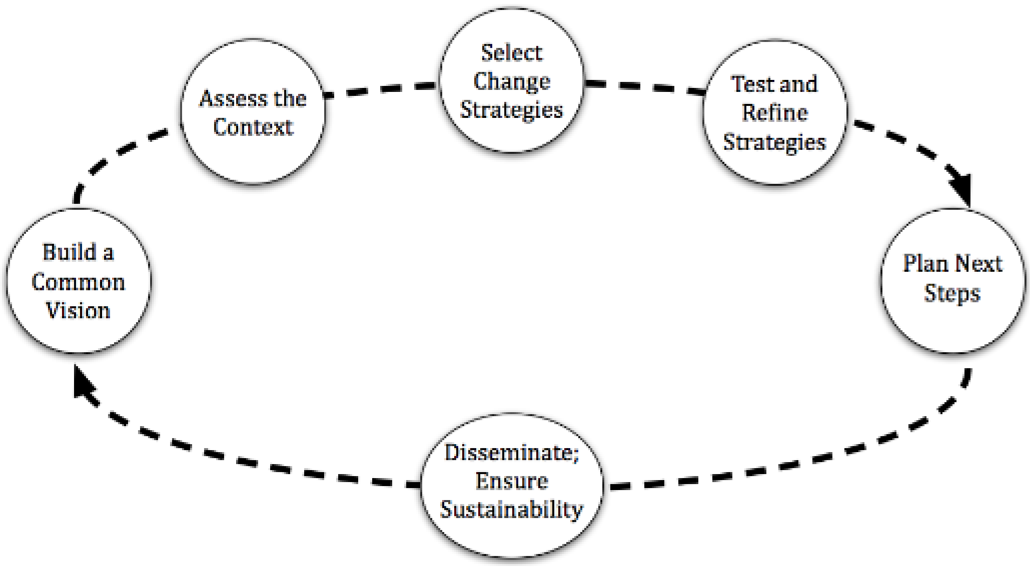


Figure 7. The ongoing and cyclic nature of improving mathematics teacher preparation programs.

There is also a specific action item in chapter nine of the AMTE Standards that addresses improvement and the process of improvement:

> **Action #4.** Faculty in programs preparing teachers of mathematics must build collaborations with faculty in other programs preparing teachers of mathematics. Learning from and with colleagues from other institutions and providers can accelerate progress in their improvement efforts, with faculty benefitting from experiences and results of each site. The *networked improvement community* model proposed by Bryk, Gomez, Grunow, and LeMahieu (2015) may be particularly useful in building knowledge across programs (cf. Martin, W. G., & Gobstein, 2015).

There is also direct mention of the MCOP^2 in reference to the work of Jeremy Zelkowski and his colleagues Stefanie Livers and Jim Gleason. So right there in the standards is another example:

> Finally, although many assessments related to mathematics teacher preparation may be mandated by university or state policy, significant benefits may ensue from including measures used across many universities. First, such common measures can be designed to align to the standards in this document, utilizing expertise across universities to provide economy of scale in their development, validation, and perhaps even scoring. Second, having common measures allows for comparisons across programs to better assess the progress being made in particular areas. For example, the Mathematics Teacher Education Partnership, a collaboration of secondary mathematics teacher preparation programs, has adopted several measures that include a common classroom-observation protocol (Gleason, Livers, & Zelkowski, 2015), a Partnership-developed survey in which candidates self-assess their readiness to teach, a Partnership-developed program self-assessment of progress along various dimensions, and a survey of the number of candidates produced by programs. These common measures are incorporated into each program's existing assessment system to provide information about the progress of the Partnership as a whole as well as the progress of individual programs in comparison to progress of the Partnership as a whole (Martin, W. G., & Gobstein, 2015). Such work also provides a foundation for collaboration on ways of using information provided by assessments and approaches to enhance teacher preparation in areas for which assessments across institutions show similar performance (joint work to design new efforts) or difference in performance (one institution with an area of strength could help partner institutions at which performance is less robust).

And the MATH RAC, the recruitment and retention RAC, has also been cited and leaned on to give some guidance on recruitment. Nicole also challenges us to change the perceptions of teaching. So those are in there. And again, I point out that those are places that were respected. These are some of the things that we are doing well.

As described in Chapter 3, the Mathematics Teacher Education Partnership Research Action Cluster (Ranta & Dickey, 2015) on recruitment has identified effective recruitment strategies for mathematics teachers. Here we revisit these strategies as they apply to attracting high school and college students to middle level majors, where they exist, or to programs leading to middle grades mathematics certification or licensure include.

- Offering field experiences in middle school mathematics settings with exemplary teachers
- Providing scholarships specific to middle level programs
- Promoting the need for middle grades mathematics teachers that exceeds the need for elementary teachers as well as for middle level English/language art or social studies teachers
- Highlighting the integrated and active-learning curriculum intended for middle grades learners
- Building a connection to the unique emotional and cognitive needs of middle grade learners
- Providing career counseling to elementary and secondary education students as well as to mathematics majors about major changes and certification options specific to middle school teaching

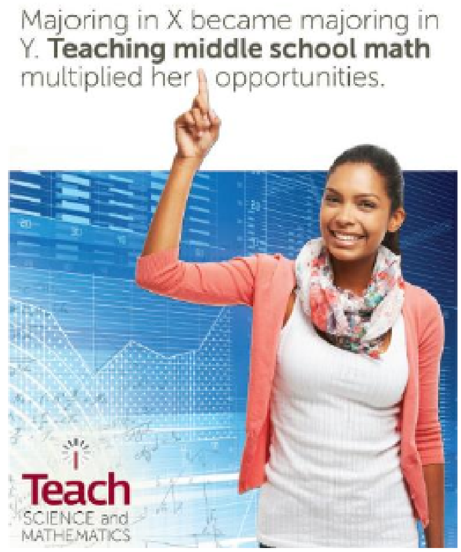


Figure 8. Excerpt from AMTE Standards about MTE-Partnership RAC work.

I think our partnership has a deep understanding of the problems of practice, and I think that's embedded in our driver diagrams and in our guiding principles. I truly see that we have embraced an evidence-based culture, and, using some of the terminology that Jennifer used in her opening, I definitely think that we have the social dimension piece of it. I think a lot of what we've gained from this is a very positive interaction among our peers that we respect -- and Josh talked about the different cultures among us -- but I think that conferences especially are a good way to foster interaction. We have shared narratives through our *Partnership Pipeline* newsletter, through the Proceedings, and through other articles that we work on collaboratively.

I attended different sessions at this conference of each of the RACs. I got a chance to see the work, and I clearly see vibrant work going on in all those different groups.

What still needs more attention? Clearly funding, and this is something the MTE-Partnership planning group has talked about, so be aware that this problem is known. Many of the RACs are securing grant funding, but that doesn't necessarily sustain the hub or the central functions of the network. So, I see that as a huge area of need. I think our working theory of improvement -- using Jennifer Russell's term -- is valid, but it continues to need review and possible modifications. And one piece that I noticed as I visited different sessions is: what is our vision of a well-prepared beginning teacher? What is our gold standard for the candidates we prepare? I'm not sure we have complete agreement on this standard. I heard some discussion in the transformation group yesterday of this and coming to terms with what our gold standard actually means is important. I use the "well-prepared beginning teacher" because that's the phrase in the *AMTE Standards*, and I think we can set what that gold standard is for our partnership, but I think at this time it is not something we clearly understand or can articulate.

The public visualization of our work, I think, is something that also needs attention, at the level of our provosts within our own institutions, as well as across the broader education community. I think we're getting notice, but I think there are other and different venues for telling our story. I heard comments from both Josh

Males and Nicole Joseph, who talked about how this could be addressed, so that there's a need for more notice of the work that's being done.

Figure 9. Five RACs at Work during 2017 New Orleans Conference, clockwise from upper left: Clinical Experiences, Program Recruitment and Retention, MODULES(S^2), STRIDES, and Active Learning Mathematics.

I also think it's very important to have some type of social connection that we experience at our annual conference over the year. This too needs some attention. I was struck by Jennifer talking about the core part of the work we do, of how important that is. And one of the things that I noticed in visiting and being part of the different RACs at the conference is that in RACs like Active Learning Mathematics, MODULE(S^2), and Clinical Experiences, the work of those RACs is very closely tied to its members' day jobs. They're school or university employment work is very closely tied to the work of the RAC. In other words, they teach calculus or pre-calculus or supervise interns and student teachers, and their teaching or supervision relates directly to the RAC work. But I also noticed that both in STRIDES, and I know from my own experience with recruitment RAC, that the RAC work for those members is on top of their regular school or university duties. We are all supervising interns or teaching methods classes, and recruitment, that's something that I'm really passionate about and care about, but I do that on top of my other duties. So I think figuring out a way to make the work of the partnership better fit the core duties of members is something that requires some level of attention.

Smith, W. M., Lawler, B. R., Bowers, J., & Augustyn, L. (Eds.). (2017). *Proceedings of the sixth annual Mathematics Teacher Education Partnership conference*. Washington, DC: Association of Public and Land-grant Universities.

I'll bring up -- this is kind of like a selfish personal reflection -- when I decided to join this partnership, my passion and purpose for joining was tied to the use of technology for teaching mathematics. However, technology did not percolate as a priority through our democratic process, but I continue to believe it's important. I also think that the role of mathematical modeling, certainly the Common Core, did not define that very clearly of how that would take place, so I think addressing how modeling receives more attention in secondary mathematics education could use attention from this partnership along with technology.

Where are we headed? Stay true to the continuous network improvement approach. I don't hear any debate of that. I think that has great efficacy. I encourage work with NCTM to impact the significant changes in high school mathematics. Clearly this was a priority of the Council and it clearly overlaps our work, so I think it's a wonderful opportunity. There is an Association for Middle Level Education (AMLE https://www.amle.org/). They are not a math organization, but it is an important group that works in middle-level education and secondary education includes middle grades. I encourage us to reach out and find some partnership with that AMLE. I think it would be mutually beneficial and the needs of middle-level students and teachers are different from those of high school students, so we are clearly concerned with secondary, and that includes both of those areas.

I think we need to continue to grow our connections to schools and districts, and I think Josh addressed that really well. We are really well-represented in mathematics education, but to a lesser degree in schools and districts, and we need more opportunities and partners in those areas.

I'm going to close with a lesson learned from my own university's long-standing professional development school network work: https://www.sc.edu/study/colleges_schools/education/partnerships_outreach/oce/schools.php. Our PDS network has been in place for some 20 years. We had leadership that was very committed to school and university partnerships. We joined the Goodlad National Network for Education Renewal (NNER), and we adopted the NNER Principles that became the Nine Essentials of the National Association of Professional Development Schools (http://napds.org/nine-essentials/), so we have a huge amount of experience in this area. One of the things that we learned in that process was: professional development schools at the high-school level are extremely difficult to establish and maintain. High schools are very different from elementary schools. So the culture of high schools in developing the professional development school network or any school improvement partnership is extremely challenging. The goal is inherently good, but there are so many different agendas involved. The history department is very different from the science department, and the school is departmentalized. One of the things that we learned is that the work in any partnership must percolate from the interests and passions of the network members, so in our professional development school network schools, we had leaders trying to say "well this is what we need to do," "we need to do this and we need to do that." And the membership didn't necessarily agree. So it's important that the leadership help focus and facilitate the priorities, but the agenda has to grow from the working members. It must grow out of the needs as well as the duties of those involved.

If we embrace Nicole Joseph's call for us to address some of the critical issues that we are facing in mathematics education, our actions must percolate from our passions. Nicole Joseph can help us focus and bring our attention to needs, but if it's not a passion for you, if this is going to be forced, it's not going to work. We have the systems in place to identify priorities and catalyze our work. So I will borrow the words that I've heard from Nicole Joseph: we will Stay Woke and we will Push Back, and I encourage you to do that.

Figure 10. Final slide of presentation.

Thank you for giving me this platform. Thank you for your collegiality and collaboration over the years.

MATHEMATICS TEACHER EDUCATION PARTNERSHIP

a project of the

Association of Public and Land-grant Universities
Science and Mathematics Teacher Initiative

www.mte-partnership.org

ISBN 978-1-5323-5553-0