Proceedings of the 10th Annual Mathematics Teacher Education Partnership Conference

The MTE-Partnership: Transformation. Equity. Leadership.

Wendy M. Smith
and
Lindsay C. Augustyn
(Editors)

APLU MTE-Partnership
Mathematics Teacher Education Partnership

June 28–29, 2021, Online
and
February 9, 2022, Hybrid
United States

Proceedings of the 10th Annual Mathematics Teacher Education Partnership Conference

Edited by Wendy M. Smith and Lindsay C. Augustyn
First published April, 2022
Published by the Association of Public and Land-grant Universities (APLU)
Proceedings available at www.aplu.org/MTE-P-2022-conference-proceedings

ISBN: 978-1-7923-9077-7

Cite Proceedings Volume as:

Smith, W. M., & Augustyn, L. C. (Eds.). (2022). *Proceedings of the 10th annual Mathematics Teacher Education Partnership (virtual) conference*. Washington, DC: Association of Public and Land-grant Universities.

Cite Proceedings Chapter as:

Author. (2022). Title of chapter. In W. M. Smith, & L. C. Augustyn (Eds.), *Proceedings of the 10th annual Mathematics Teacher Education Partnership (virtual) conference* (pp. XX–XX). Washington, DC: Association of Public and Land-grant Universities.

Mathematics Teacher Education Partnership Co-Directors

W. Gary Martin, Auburn University
Wendy M. Smith, University of Nebraska–Lincoln
Howard Gobstein, Association of Public and Land-grant Universities

Mathematics Teacher Education Partnership Planning Committee

W. Gary Martin, Auburn University, co-chair
Dana Franz, Mississippi State University
Brian R. Lawler, Kennesaw State University
Alyson Lischka, Middle Tennessee State University
Margaret J. Mohr-Schroeder, University of Kentucky
Wendy M. Smith, University of Nebraska-Lincoln
Marilyn E. Strutchens, Auburn University
John Sutton, ResultED LLC
Fred Uy, California State University, Chancellor's Office

Acknowledgments

Funding for the MTE-Partnership, including the 2022 Conference, was provided in part by grants from the National Science Foundation (DUE-1834539 and DUE-1834551)[1].

Special thanks to Stephanie Vendetti and Lindsay Augustyn of the University of Nebraska–Lincoln and Ny'lyjah Cain of APLU for their assistance in planning and executing the logistics for the 2021–22 MTE-Partnership Conference.

Preface

These proceedings are a written record of the presentations and papers presented at the 10th Annual Mathematics Teacher Education Partnership Conference held online, June 28–29, 2021, and as a pre-conference Feb. 9, 2022. The theme was "The MTE-Partnership: Transformation. Equity. Leadership." We are pleased to present these Proceedings as a resource for the mathematics and mathematics education community.

www.mte-partnership.org

ISBN 978-1-7923-9077-7
90000>
9 781792 390777

[1] 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.

CONTENTS

INTRODUCTION

RESEARCH ACTION CLUSTER REPORTS

BRIEF REPORTS

CONTINUED

Research Papers

Introduction

The MTEP 2.0 Network: The Journey to Transform Secondary Mathematics Teacher Preparation Continues

W. Gary Martin, Auburn University, martiwg@auburn.edu
Wendy M. Smith, University of Nebraska–Lincoln, wsmith5@unl.edu
Marilyn E. Strutchens, Auburn University, strutme@auburn.edu
Alyson E. Lischka, Middle Tennessee State University, Alyson.Lischka@mtsu.edu
Dana Pomykal Franz, Mississippi State University, df76@colled.msstate.edu

The Mathematics Teacher Education Partnership (MTE-Partnership) is a coalition of mathematics teacher preparation programs launched in 2012 to improve secondary mathematics teacher preparation using the networked improvement community (NIC) design (Bryk, 2020; Bryk et al., 2015). With the release of the Association of Mathematics Teacher Educators' (2017) *Standards for the Preparation of Teachers of Mathematics* (AMTE Standards), the MTE-Partnership pivoted to focus on meeting the vision for mathematics teacher preparation presented in that document, noting that meeting that vision is often challenging: "Those involved in mathematics teacher preparation must be committed to improving their effectiveness in preparing future teachers of mathematics" (AMTE, 2017, p. 2). In particular, "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" (AMTE, 2017, p. 166). The NIC design is an effective way of organizing such collaborations, as demonstrated by the progress of the MTE-Partnership Research Action Clusters (RACs) in addressing significant problems of practice (Martin et al., 2020). However, a further adaptation was introduced in 2020 with the launch of the "MTEP 2.0" network, which refocused the NIC model on guiding local program improvement work as well as cross-institutional work (Franz et al., 2020). The 2021 conference marked the 10th annual convening of the MTE-Partnership and was explicitly designed to accelerate the development of the MTEP 2.0 network. This chapter describes the initial design and launch of the MTEP 2.0 network, as well as the resources provided to further support the development of the local program NICs through the conference and other avenues.

The Design of MTEP 2.0

During the initial years of the MTE-Partnership, the focus was on establishing the MTE-Partnership as a NIC, following four essential characteristics (Bryk et al., 2015):

- **Focused on a well-specified common aim:** An improvement aim expresses "lofty goals and specifies operational targets" (Bryk et al., 2015, p. 150). It serves to provide both focus across the NIC on actions that promote movement to the aim and as a motivation for members so they feel part of a common narrative.
- **Guided by a deep understanding of the problem space and the underlying system:** Improvements seek to achieve sustainability by first understanding the root causes (systemic factors) of the identified problem of practice, and then determining change levers and associated strategies for moving those

levers. The levers for change are sometimes called *change drivers*; NICs typically create a driver diagram to map their planned changes and relationships among hypothesized change drivers (Bryk et al., 2015).

- **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. Plan-Do-Study-Act (PDSA) cycles 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).
- **Networked to accelerate progress:** Rather than trying to control variation, as typical in traditional educational research, the NIC 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 be gradually spread across the network, supporting scale up (Bryk et al., 2015). Further note that the structure of the network allows a divide-and-conquer approach in which subsets of membership can address different problem areas in parallel.

The MTE-Partnership's early driver diagrams led to the organization of RACs, each focused on one of four primary drivers: clinical experiences, active learning, mathematics content courses, novice teacher induction, and program recruitment and retention (Martin & Gobstein, 2018). This cross-institutional focus led to productive collaborations and significant progress in these areas (Franz et al., 2020).

However, the MTE-Partnership leaders came to realize that while cross-institutional collaborations in RACs were flourishing, the focus was not always on supporting local mathematics teacher preparation programs in making the necessary improvement to meet the ATME Standards (2017). Thus, MTEP 2.0 was launched in 2020 with a renewed focus on local teams' transformation efforts and on associated MTE-Partnership-wide research to understand how the MTE-Partnership was supporting local transformation efforts (Franz et al., 2020). MTEP 2.0 is structured as a NIC-of-NICs in which local programs organize as NICs working toward locally defined aims related to program transformation, along with cross-NIC efforts including existing and emerging RACs focusing on common problems of practice. The overarching MTEP 2.0 NIC-of-NICs provides the hub structures to share knowledge across local program NICs, while also providing support and resources to those NICs. The local NICs have a variety of sizes and structures, from a single university-based teacher preparation program and one local school-district partner, to entire university systems with both local and state-level school and community partners.

The MTE-Partnership leaders developed the following aim for the MTEP 2.0 network:

> *By 2025, 65 MTEP 2.0 programs (including 11 under-resourced institutions and/or minority-serving institutions) will be actively engaged in an explicit, localized, prioritized improvement process toward alignment with the AMTE Standards and MTEP (2020) Guiding Principles in order to increase the number of well-prepared beginning secondary mathematics teachers, foregrounding issues of equity and access both in the objectives and practices of the programs.*

The leaders further developed the primary drivers outlined in Figure 1 to guide the work of the NIC-of-NICs. The work of program transformation is complex; driver diagrams help focus stakeholders' efforts while avoiding seemingly endless tangents that can distract from progress toward the NIC aim.

MTEP 2.0 Primary Drivers

Change Agents	Change agents leading transformation efforts
Knowledge Building	Building overall knowledge about program transformation
Knowledge Sharing	Generating, capturing, and promoting knowledge useful to MTEP 2.0 teams
Network Building	Scaling up and nurturing a national network of Program NICs
Responding to Context	Engaging stakeholders across Program NICs in creating, assessing, and responding to policies
Outreach	Building external awareness and support of the MTEP network

Figure 1. MTE-Partnership 2.0 primary drivers, as of July 2021.

The Launch of MTEP 2.0

At the 2020 MTE-Partnership Conference, local program teams were initiated in a process of organizing their work following the NIC model (Franz et al., 2020), with final applications to join the MTEP 2.0 network due October 15, 2020. Each MTEP 2.0 NIC has developed (and in most cases refined) an aim and driver diagram to guide its efforts. Aims and drivers necessarily require periodic updates as progress is made, local contexts and policies shift, and stakeholders turn over. MTEP 2.0 NICs also had completed at least one PDSA cycle by the application deadline, with the expectation that they complete at least one additional cycle each semester thereafter.

In alignment with NIC structures, MTEP 2.0 established data collection procedures that allow it to learn from the work of its partners, with an "aim to learn what works, for whom, and under what set of conditions" (Bryk et al., 2017, p. 172) as progress is made to transform toward the AMTE Standards (2017). To that end, the collection of reports that include local NICs' driver diagram revisions, PDSA cycles, data on program growth, and other records of local NIC progress occurs annually. Analysis of this data allows the MTE-Partnership to consider variation across contexts in the work of program improvement and then share results with members. The MTE-Partnership has established OpenCanvas as both a data collection point and a knowledge management system, where members can share information and find resources for program improvement. This report explores the initial findings in two major areas: establishing partnerships and priorities for the improvement work.

Establishing Partnerships

MTEP 2.0 emphasizes the importance of including stakeholders, especially those groups outside of the local institution, in the design of the local NICs. This emphasis directly aligns with AMTE standard P.1: *An effective mathematics teacher education program has significant input from all appropriate stakeholders* (AMTE, 2017). During the MTE-Partnership annual conference in 2020, NICs were provided time to engage in a root cause analysis specifically to brainstorm the stakeholders who needed to be part of the NIC work that would result in program transformation.

Currently, MTEP 2.0 consists of 19 partnership teams from 17 states, including 44 programs, with 12 teams having at least one member from a land-grant institution, and eight teams counting a minority-serving institution in their membership; the partnership teams collectively prepare over 600 future mathematics teachers annually. MTEP 2.0 requires all NICs to have K–12 representation. Analysis of the annual team reports reveals Partnerships (n=7) as a recurring keyword. NICs continue to remake their team as they recognize key stakeholders that will help them meet their aim.

Priorities for Improvement

From the NICs that applied to be part of MTEP 2.0 (n=19), the aims and driver diagrams reveal that all but one explicitly focus on improving diversity (n=10) and/or equity (n=11) in their teacher preparation program. In line with the overall MTE-Partnership aim to increase the quantity of well-prepared mathematics teachers, the most common driver across MTEP 2.0 NICs is related to recruitment into teacher preparation programs (n=14). A quarter to a third of the MTEP 2.0 NICs have drivers related to forming a shared vision among stakeholders (n=7) or strengthening or expanding their partnership with their stakeholders (n=5) as discussed in the previous section, restructuring their preparation program (n=6), retention through the preparation programs (n=5), and aligning their programs with the AMTE Standards (2017) (n=6). Table 1 shows major categories of change drivers along with wording of representative drivers from MTEP 2.0 driver diagrams.

Table 1

MTEP 2.0 Summary of 19 NIC Driver Diagrams

CATEGORY	**N**	**EXAMPLE DRIVER**
Recruitment	14	Understand how to connect with community college students who are future teachers of mathematics.
Diversity	10	Develop strategies to effectively recruit diverse candidates in the categories of incoming freshman, transfer students, and undeclared students and expand our recruitment efforts to include our K–12 partners.
Equity	11	Be more intentional about infusing equity throughout all K–12 partnership activities, university coursework, and clinical experiences.
Shared vision	7	Develop shared vision of good mathematics teaching and for the purpose of mathematics education across stakeholders.
Institutional structure	6	Find creative ways to expand the scope and length of the clinical experience.
Aligning to AMTE Standards	6	Establish a coherent system of content, pedagogy, and field experiences (e.g., courses) aligned with the AMTE Standards.
Effective teaching	6	Math teacher educators will learn about best practices and then promote/teach these best practices with pre- & in-service teachers.
Retention	5	Ensure our incoming students are prepared for Calculus I in their first semester. (Retention)
Partnerships	5	Develop effective partnerships (within and across institutions, stakeholders) to support mathematics teacher preparation.
Policy	5	Research and advocate for policy changes that show potential for increasing diversity in the workforce.

Other (data, mathematical knowledge, mentoring, clinical experiences, community, induction)	16	Build community early among math education majors. Ensure program graduates have the supports they need to be retained in the field.

Supporting the MTEP 2.0 Network

Since the MTEP 2.0 network was officially launched in Fall 2020, significant efforts have been initiated by the MTEP 2.0 NIC-of-NICs to support the local teams in their use of the NIC model to guide their improvement efforts. To begin, the 2021 MTE-Partnership Conference, a three-day event held in June, had a central focus on accelerating the teams' progress. Then, a pre-conference was held in conjunction with the AMTE Annual Conference in February 2022. Finally, this report describes continuing support offered throughout the year.

2021 MTE-Partnership Conference

The conference was held virtually due to limitations in travel faced at most institutions involved with MTEP 2.0. Four working sessions were held across the first two days of the session; sessions focusing on the RACs were held on the third day. Each of the working sessions focused on a different aspect of how to initiate and support program transformation and, by design, had a primary focus on facilitating interactions across the members of the MTEP 2.0 teams in alignment with the networked characteristics of the NIC model. In addition, the MTEP 2.0 members were encouraged to collaborate in time provided between sessions. Overviews of the sessions follow.

- **Developing leadership capacity for local change.** Participants engaged in reading about and discussing characteristics of effective leaders, and then engaging in a round of discussions about local program NIC leaders. Participants were encouraged to add ongoing team-building to their driver diagram and PDSA cycles.
- **Cross-NIC collaboration to accelerate transformation efforts.** Teams participated in constructive listening and feedback small group sessions in which they described a PDSA cycle and sought feedback on next steps to continue growth. These structured discussions promoted sharing across program NICs to generate collaboration across institutions.
- **Navigating policy issues to support program transformation.** A panel of administrators from both K–12 and higher education discussed their take on how policy impacts secondary mathematics teacher preparation. Teams then met in breakout rooms to discuss issues facing their programs, followed by responses from the panel. A final breakout session focused on potential opportunities and solutions, with final responses from the panel.
- **Foregrounding equity and social justice in program transformation.** In this session, teams reflected on the value of maintaining an equity lens on local transformation efforts in secondary mathematics teacher preparation. They were introduced to two frameworks useful in this enterprise: A Racial Justice in Education framework (National Education Association, 2021) to provide deeper insight into transformation in secondary math teacher preparation and the Four Frames for Systemic Change framework (Reinholz & Apkarian, 2018) to better understand local transformation efforts.

This proceedings was developed to provide additional information that could not be directly provided during the conference due to the schedule limitations imposed by its virtual format. Two types of papers were invited: (a) brief reports documenting program NIC or RAC progress in a PDSA cycle or related transformation work to make progress toward your aims, or (b) research papers reporting on more formal research conducted related to the MTE-Partnership's overall aim and guiding principles.

2021 AMTE Pre-conference

A one-day virtual meeting was held prior to the AMTE Annual Meeting in February 2022. Two sets of breakout sessions were held. The first set of breakouts focused on the NIC model and was differentiated by level of interest and involvement in MTEP 2.0, including: (a) a session designed for those already engaged in MTEP 2.0 to help them develop leadership skills for change; (b) a session designed for those aware of and interested in pursuing an application to MTEP 2.0 on behalf of their institution; and (c) a session for those not familiar with MTEP 2.0 to provide them an overview of the NIC design. A second set of breakout sessions focused on particular areas of challenge in secondary mathematics teacher preparation, including recruiting and retaining diverse mathematics teacher candidates; promoting equitable practices in secondary mathematics teacher preparation; partnerships to support program transformation in secondary mathematics teacher preparation; and policy and institutional structures to support program transformation. As was the case with the MTE-Partnership Conference, significant opportunities for sharing across contexts was provided in all sessions. Note that a pre-conference also is planned to be held prior to the AMTE Annual Meeting in February 2023.

Continuing Supports

A variety of additional supports are provided by the MTEP 2.0 NIC-of-NICs. Perhaps most visible are monthly NIC-Casts, interactive webinars that provide opportunities for local NICs to engage with one another around improvement science ideas. These webinars are recorded and stored in OpenCanvas and therefore available as a resource for local NICs and as data for learning about program improvement. This structure allows smaller local NICs to pool data, leveraging collaboration to support informed decision making toward improvement. In addition, each team has been assigned a coach from the MTEP 2.0 planning team with whom they can interact throughout the year.

MTEP 2.0: The Whole Is Greater Than the Sum of the Parts

When the MTE-Partnership NIC was initially built in 2012, many of the leadership team felt that the power of the NIC was that they would be able to address problems of practice needed to improve their local programs. Moreover, use of the positive peer pressure resulting from examples of how other MTE-Partnership institutional members were going through similar transformations and how they had the support of their administrators to make similar changes emerged as powerful change levers across the MTE-Partnership NICs. As leaders have worked together in the RACs and other subgroups, they realized that the NIC is powerful in multiple ways—some of which we had not anticipated. Also, leaders are beginning to realize the power of the NIC model in guiding local transformation efforts in concert with global, cross-institutional collaborations. These researchers have found it essential that a culture of improvement propagates across those working to prepare teachers of mathematics, not only in the immediate contexts in which they work but also as a global, shared commitment of improvement. Despite its 10-year history, in some sense the MTE-Partnership journey is just beginning as it continues to seek ways to better support program improvement efforts. The leadership team aims to continue to contribute to the broader improvement journey of mathematics teacher preparation and to learn from others who join them in this journey.

References

Association of Mathematics Teacher Educators (2017). *Standards for preparing teachers of mathematics*. Author.

Bryk, A. S. (2020). *Improvement in action: Advancing quality in America's schools.* Harvard Education Press.

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

Franz, D., Lawler, B. R., Lischka, A., Martin, W. G., Mohr-Schroeder, M., Smith, W. M., Strutchens, M., Sutton, S., & Uy, F. (2020). MTEP 2.0: Launching a new focus on program transformation. In W. M. Smith & L. C. Augustyn (Eds.), *Proceedings of the ninth annual Mathematics Teacher Education Partnership conference.* Association of Public and Land-grant Universities.

Martin, W. G., Lischka, A. E., Smith, W. M., & Lawler, B. R. (Eds.) (2020). *The Mathematics Teacher Education Partnership: The power of a networked improvement community to transform secondary mathematics teacher preparation.* Volume 4 in B. Benken (Ed.), Association of Mathematics Teacher Educators Professional Book Series. Information Age Publishing.

Martin, W. G. & Gobstein, H. (2018). The Seventh Annual MTE-Partnership Conference: Equity, Transformation, Leadership. In W. M. Smith, B. R. Lawler, J. F. Strayer, & L. Augustyn, L. (eds.), *Proceedings of the seventh annual Mathematics Teacher Education Partnership conference*. Association of Public and Land-grant Universities.

Mathematics Teacher Education Partnership. (2020). *Updated guiding principles for the improvement of secondary mathematics teacher preparation*. https://www.mtep.info/guiding-principles

National Education Association. (2021). Racial justice in education framework. https://www.nea.org/resource-library/racial-justice-education-framework

Reinholz, D. L., & Apkarian, N. (2018). Four frames for systemic change in STEM departments. *International Journal of STEM Education, 5*(3), 1–10.

RESEARCH ACTION CLUSTER REPORTS

Active Learning Mathematics (ALM)

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

Problem Addressed & General Approach

The Active Learning Mathematics Research Action Cluster (ALM RAC) was formed to address the ongoing problems of undergraduate student success in first-year mathematics courses, Precalculus through Calculus 2 (P2C2). Over 90% of 2.5 million students in the United States who take collegiate mathematics courses each year are taking courses at or below Calculus 2 (Johnson, 2019). Student success in first year mathematics courses (or lack thereof) can prompt changes in decisions to pursue STEM majors; student retention from first to second year and the four- and six-year graduation rates are highly correlated with grades in first year mathematics courses (in large part because mathematics courses are a near-universal requirement for graduation). Active learning strategies can improve student engagement and learning outcomes, but instructors need professional development and ongoing support to positively change their teaching practices. Further, different in-class materials (activities) are needed to better engage students.

The ALM RAC activities are detailed in its driver diagram (see Figure 1). Related to curriculum and assessment, ALM RAC partners work to develop and share materials that can support active learning, and also promote local coordination of assessment, through common homework, exams, and grading. Instructor capacities are addressed through initial and ongoing professional development; graduate student instructors are a unique (rotating) population of P2C2 instructors who need targeted supports. Student dispositions are measured via common surveys and other outcome measures. Focusing on a common vision entails significant will-building and local leadership to navigate policies and barriers, as well as to activate change levers (such as hiring and empowering a course coordinator).

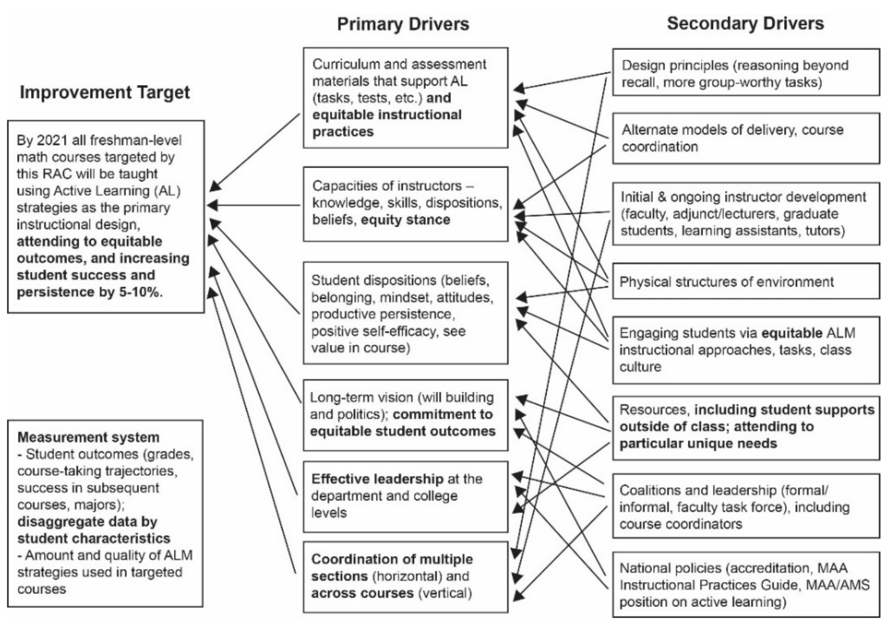

Figure 1. The ALM RAC Driver Diagram was revised in 2019 to include leadership as a primary driver and to update the secondary drivers.

Whereas ALM RAC members are focused on their own transformation efforts, a related coalition is studying how to effect departmental transformation to adopt and sustain active learning strategies. The Student Engagement in Mathematics through an Institutional Network for Active Learning (SEMINAL) project is a collaborative grant among the Association of Public and Land-grant Universities, the University of Colorado Boulder, the University of Nebraska–Lincoln, and San Diego State University (DUE-1624643, 1624610, 1624628, 1624639). Now in Year 5, SEMINAL's research findings related to change levers for active learning, and sustaining departmental transformation efforts are aligned with ALM RAC efforts (Smith et al., 2021).

Current Progress

As a note, the extra stressors on members' time throughout the COVID-19 pandemic limited participation in the ALM RAC during 2020 and spring 2021. Prior to the pandemic, the ALM RAC contributed a chapter to the 2020 Mathematics Teacher Education Partnership, summarizing our work to date and including multiple vignettes (Smith, Callahan, Mingus, & Hodge, 2020); one section of the book is focused on the mathematical content preparation of future teachers and also includes an overview chapter that is relevant to ALM RAC.

During fall 2020, our ALM RAC monthly meetings largely focused on teaching during a global pandemic, including engaging students remotely/from a distance; sharing and exploring various online tools (e.g., Jamboard, Teacher Desmos); assessing students remotely; and how to influence others to engage in transformation work. Our thematic work follows both our driver diagram and the interests and needs of the members attending our meetings.

Resources and Opportunities for Engagement

The ALM RAC welcomes additional partners who want to engage, from helping to develop a dynamic repository of materials, to engaging in lesson study for P2C2 lessons. During 2021–2022 we will have monthly meetings (contact Wendy Smith to be added to the ALM RAC email list). 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 note that the 2018 publication by the MAA of an *Instructional Practices Guide*, has many excellent principles for actively engaging students in learning mathematics. This publication is a great resource for helping to start local conversations about mathematics teaching and learning and has many practical tips for increasing student engagement. The SEMINAL project has a new book (Smith et al., 2021) that focuses on how departments changed their cultures to sustain active learning as the norm for first year mathematics teaching and learning. Local teams can implement or increase course coordination; coordination can help to sustain improvements and address inequitable student experiences and outcomes. *PRIMUS* released a special three-issue volume in 2020 focused on mathematics departments in the early stages of changes to adopt active learning strategies. The full list of those publications is in the reference list. Finally, those interested in improving P2C2 teaching and learning need to approach departmental transformation systemically, recruiting key leaders within and above the mathematics department in order to effectively initiate, implement, and sustain changes.

References and Resources

Apkarian, N. (2018). Transforming precalculus to calculus 2: A longitudinal study of social and structural change in a university mathematics department. PhD thesis, University of California San Diego and San Diego State University, San Diego, CA.

Apkarian, N., Smith, W. M., Vroom, K., Voigt, M. K., & Gehrtz, J. (2019). *X-PIPS-M Survey Suite*. https://www.maa.org/programs/faculty-and-departments/curriculum-development-resources/national-studies-college-calculus/ptc-publications

Ellington, R., Barber, J., Tannouri, A., Syafrida, S., & Nkwanta, A. (2020). The MSU SEMINAL Project: Incorporating Principles of Culturally Responsive Teaching in a Pre-Calculus Course. *PRIMUS*, *31*(3–5), 296–315. https://doi.org/10.1080/10511970.2020.1805661

Gruber, S., Rosca, R. I., Chazan, D., Fleming, E., Balady, S., VanNetta, C., & Okoudjou, K. A. (2020). Active Learning in an Undergraduate Precalculus Course: Insights from a Course Redesign. *PRIMUS*, *31*(3–5), 358–370. https://doi.org/10.1080/10511970.2020.1772920

Johnson, E. (2019). Undergraduate mathematics instruction: Not as bad as you'd think? In S. Laursen (Ed.) *Levers for change: An assessment of progress on changing STEM Instruction* (pp. 100–122). American Association for the Advancement of Science. Retrieved from: https://www.aaas.org/sites/default/files/2019-07/levers-for-change-WEB100_2019.pdf

Lange, K. E., Deiger, M., Bourque, M., Tingley, P., Peters, E., Jordan, L. E., & Giaquinto, A. (2020). The Collaborative Development of Active Learning at Loyola University Chicago as Part of the SEMINAL Network. *PRIMUS*, *31*(3–5), 281–295. https://doi.org/10.1080/10511970.2020.1772921

Martin, W. G., Lawler, B. R., Lischka, A., & Smith, W. M., (Eds.) (2020). *The Mathematics Teacher Education Partnership: The power of a networked improvement community to transform secondary mathematics teacher preparation.* Volume 4 in B. Benken (Ed.), Association of Mathematics Teacher Educators Professional Book Series. Charlotte, NC: Information Age Publishing.

Mathematical Association of America (2018). *Instructional practices guide.* Retrieved from: https://www.maa.org/programs-and-communities/curriculum%20resources/instructional-practices-guide

Miller, E., Fowler, J., Johns, C., Jr., J. J., Ramsey, B., & Snapp, B. (2020). Increasing Active Learning in Large, Tightly Coordinated Calculus Courses. *PRIMUS*, *31*(3–5), 371–392. https://doi.org/10.1080/10511970.2020.1772923

Moore-Russo, D., Kornelson, K., Savic, M., & Andrews, C. (2020). Considering the Evolution of the STEM Mathematical Pathway at the University of Oklahoma Using Organizational Development and Change Theory. *PRIMUS*, *31*(3–5), 343–357. https://doi.org/10.1080/10511970.2020.1793852

Oliver, J., & Olkin, J. (2020). A Community of Practice Model for Infusing Active Learning in the Classroom. *PRIMUS*, *31*(3–5), 252–268. https://doi.org/10.1080/10511970.2020.1746452

Smith, W. M., Callahan, K., Mingus, T., & Hodge, A. (2020). *Active learning mathematics research action cluster.* In W. G. Martin, A. Lischka, W. M. Smith and B. R. Lawler (Eds.), *The Mathematics Teacher Education Partnership: The power of a networked improvement community to transform secondary mathematics teacher preparation* (pp. 143–178). Volume 4 in B. Benken (Ed.), Association of Mathematics Teacher Educators Professional Book Series. Charlotte, NC: Information Age Publishing.

Smith, W. M., Rasmussen, C., R., & Tubbs, R. (2021). Introduction to the special issue on infusing active learning into precalculus and calculus courses: Insights and lessons learned from mathematics departments in the process of change. *PRIMUS, 31*(3–5), 239–251.

Smith, W. M., Voigt, M., Strom, A., Webb, D. C., & Martin, W. G., (Eds.) (2021). *Transformational change efforts: Student engagement in mathematics through an institutional network for active learning.* American Mathematics Society and the Conference Board on Mathematical Sciences.

Soto, R. C., & Marzocchi, A. S. (2020). Learning about Active Learning While Actively Learning: Insights from Faculty Professional Development. *PRIMUS*, *31*(3–5), 269–280. https://doi.org/10.1080/10511970.2020.1746449

Vandenbussche, J., Ritter, L., Callahan, K. M., & Westlund, E. E. (2020). Using Strand Committees to Build Faculty Support for Departmental Change. *PRIMUS*, *31*(3–5), 330–342. https://doi.org/10.1080/10511970.2020.1772916

Villalobos, C., Kim, H. W., Huber, T. J., Knobel, R., Setayesh, S., Sasidharan, L., Galstyan, A., & Balogh, A. (2020). Coordinating STEM Core Courses for Student Success. *PRIMUS*, *31*(3–5), 316–329. https://doi.org/10.1080/10511970.2020.1793855

Voigt, M. K. (2017). Equity and active learning. in *Proceedings of the Sixth Annual Mathematics Teacher Education Partnership Conference.* Association of Public and Land-grant Universities.

Voigt, M. K. (2020). *Queer-spectrum student experiences and resources in undergraduate mathematics*. PhD thesis, University of California San Diego and San Diego State University, San Diego, CA.

Appendix A

ALM RAC 2019–2020 Progress on Primary Drivers

Curriculum and assessment materials that support AL (tasks, tests, etc.) and equitable instructional practices
Each campus is building its own set of materials; many pull from University of Colorado materials. Textbook selection can be contentious and supports or inhibits ALM adoption. Building local materials can be a way to get people on board (ownership); sharing materials in useable form is an ongoing consideration (OneDrive, Google Drive, WikiSpace, Dropbox)
Capacities of instructors – knowledge, skills, dispositions, beliefs, equity stance
ALM RAC members each doing instructor professional development of some type (formal or informal) with instructors (including graduate student instructors, undergraduate learning assistants)
Student dispositions (beliefs, belonging, mindset, attitudes, productive persistence, positive self-efficacy, see value in course)
Some ALM RAC members are surveying students. Campuses engaged in comprehensive transformation efforts seem to be improving student outcomes. Some ALM RAC members are preparing to use the EQUIP tool as a mechanism for collecting equity-related data for class participation.
Long-term vision (will building and politics); commitment to equitable student outcomes
Each ALM RAC member working on this; a key focus of ALM RAC meetings is sharing current lessons learned. Challenges to scaling up are often due to lack of buy-in. In some cases, collecting local data is (or is the foundation for) getting more people on board that there is a problem.
Effective leadership at the department and college levels
As a new driver, ALM RAC members are having ongoing conversations about how to effectively be leaders on their local campuses, how to work with formal leaders in and beyond the mathematics department, and how to frame ALM RAC work to align with leaders' priorities for campuses.
Coordination of multiple sections ("horizontal") and across courses ("vertical")
Each ALM RAC member is working on better coordination, along with hiring/designating coordinators. Getting buy-in for common assessments and common grading is a tough sell in some locations. Coordination can be argued as a structure for increasing equitable outcomes.

MODULE(S^2): Mathematics of Doing, Understanding, Learning, and Educating for Secondary Schools

Alyson E. Lischka, Middle Tennessee State University, Alyson.Lischka@mtsu.edu

Problem Addressed & General Approach

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') mathematical knowledge needed for teaching (Ball et al., 2008; Rowland, 2013) within upper-level content courses. The work of the RAC aims to address the identified problems that (a) PSMTs often do not find connection between upper-level mathematics content courses and teaching secondary mathematics (Goulding et al., 2003; Zazkis & Leikin, 2010) and (b) PSMTs must deeply understand the mathematics they are going to teach and learn it in a way that is consistent with expectations of them as teachers (Banilower et al., 2013).

In response to these problems, the MODULE(S^2) RAC has collaborated with mathematicians, mathematics educators, and K–12 teachers to design 12 educative curriculum (Davis & Krajcik, 2005) modules in the content areas of Geometry, Algebra, Statistics, and Mathematical Modeling. Each module includes opportunities for PSMTs to engage in mathematical tasks that are set in explicitly pedagogical settings, for the purpose of developing PSMTs' mathematical knowledge for teaching (MKT). The MODULE(S^2) RAC iteratively pilots and revises the materials to: understand how to support instructors in implementing the materials; understand the ways in which dissemination of the modules across a wide range of institutions can vary; and improve the quality of the modules, specifically in terms of developing PSMTs' MKT.

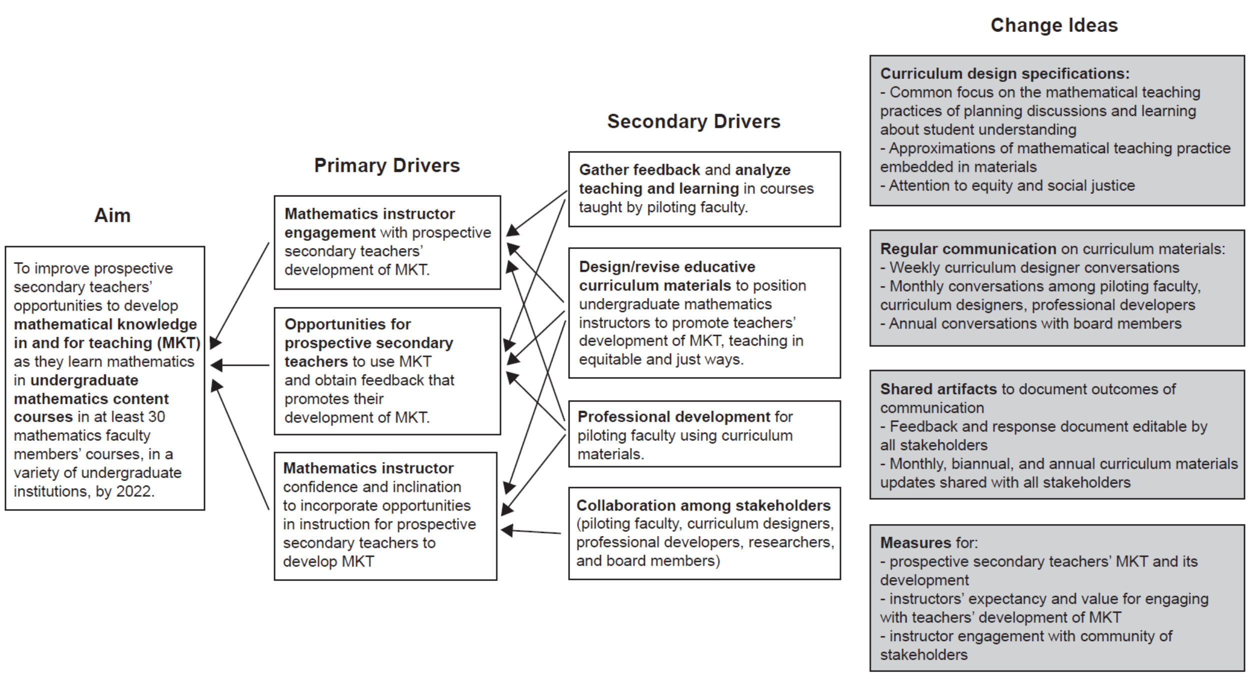

Figure 1: MODULE(S^2) Driver Diagram.

Work of this RAC is structured according to its driver diagram (see Figure 1). For the last three years, the RAC has focused on the development of materials and understanding how to support piloting instructors in the enactment of the materials. That work continues as we prepare for the final iteration of piloting in 2021–2022. In addition, the RAC is turning attention to broadening the dissemination of the materials and supporting programs in implementing the MODULE(S^2) materials as part of program transformation efforts.

Current Progress

With interruptions in instruction and academic work due to COVID-19, the project team re-evaluated timelines and made plans to shift its focus for 2020–2021. Instead of piloting in two content areas as planned, the team paused major piloting efforts and turned its attention to data analysis, revision of materials, and shifting its professional development model to an online format.

Data collection from piloting efforts has now accumulated enough data to begin answering questions related to the implementation of the materials such as those involving: PSMTs' MKT as influenced by engaging with the materials, comparisons across PSMTs' expectancy and value for using core teaching practices as influenced by engaging with the materials, and the ways in which piloting faculty engage in professional learning for the materials. One such report can be found in this proceedings (see Strayer et al., this volume) and others are cited on the *Presentations and Publications* page of the MODULE(S^2) website (www.modules2.com). As we move forward, we expect that courses in which the MODULE(S^2) materials are implemented can be a rich site for investigation of questions that inform program transformation in content courses.

Each instance of piloter implementation provided feedback from both the instructors and the prospective teachers in their classes (in the form of surveys and assignments collected), in essence this is data for the Study portion of the Plan-Do-Study-Act cycles for the writing of the materials. The MODULE(S^2) team uses this feedback to revise the materials. With a pause in extensive piloting, project team members took up existing feedback to incorporate improvements in the materials.

Finally, the pause in piloting due to COVID-19 provided time for the MODULE(S^2) professional development team to convert its prior in-person professional learning segments to remote experiences. The team has prepared a series of asynchronous and synchronous virtual activities to be delivered through its Canvas space to support the 2021–2022 piloters. Plans moving forward include considering ways these activities may live on in an asynchronous virtual support environment for the community of MODULE(S^2) materials users we hope to develop.

The MODULE(S^2) RAC meeting at the 2021 MTE-Partnership Conference will build on discussions held at the 2020 MTE-Partnership Conference. The major results of the 2020 Conference discussions were: identifying the potential for this RAC to advocate for the transformation of mathematics courses to use MODULE(S^2) materials and be considered appropriate for all mathematics majors; identifying the need for making literature related to discussion-based courses available to the MTE-Partnership institutions; and identifying ways the MODULE(S^2) materials could be used to bring attention to issues of social justice and racism (Lischka & Czap, 2020). The RAC did not meet during 2020–2021, thus these conversations will be continued at the 2021 MTE-Partnership Conference. In particular, the RAC will move forward with drafting resource briefs to provide support to MTE-Partnership institutions interested in taking up or continuing program transformation in content courses. Briefs will include resources and suggestions to support implementation of MODULE(S^2) materials and will be published in Canvas upon completion.

Resources

A selection of MODULE(S^2) materials is currently available for download at www.modules2.com, along with promotional videos and other information about the MODULE(S^2) project and the research produced. At the website, interested instructors also can learn how to access materials. The final year of piloting across all four content areas will be conducted in 2021–2022. Following the completion of piloting, all materials, along with professional development modules to support implementation, will be made freely available in Canvas for any instructors who request access through the MODULE(S^2) website. The briefs produced by the RAC in the 2021 MTE-Partnership Conference will be published to the MTE-Partnership Canvas page, for use by all MTEP institutions.

Opportunities for Engagement

The MODULE(S^2) RAC invites members to join conversations about the future work of this RAC. Please contact Alyson.Lischka@mtsu.edu if you wish to be included in these conversations. Use of the MODULE(S^2) materials can be accessed through www.modules2.com.

Work on this chapter was supported in part by a grant from the National Science Foundation IUSE (Improving Undergraduate STEM Education) multi-institutional collaborative grant #1726707 (APLU), #1726098 (University of Arizona), #1726252 (Eastern Michigan University), #1726723 (Middle Tennessee State University), #1726744 (University of Nebraska–Lincoln), and #1726804 (Utah State University). All findings and opinions are those of the authors, and not necessarily those of the funding agency.

References

Ball, D., Thames, M. H., & Phelps, G. (2008). Content knowledge for teaching: What makes it special? *Journal of Teacher Education, 59*, 389–407.

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.* Horizon Research, Inc.

Davis, E. A., & Krajcik, J. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher, 34*(3), 3–14.

Goulding, M., Hatch, G., & Rodd, M. (2003). Undergraduate mathematics experience: Its significance in secondary mathematics teacher preparation. *Journal of Mathematics Teacher Education, 6*, 361–393.

Lischka, A. E., & Czap, L. (2020). The mathematics of doing, understanding, learning, and educating for secondary schools RAC report. In W. M. Smith, B. R. Lawler, J. F. Strayer, & L. Augustyn (Eds.), *Proceedings of the seventh annual Mathematics Teacher Education Partnership conference* (pp. 63–67). Association of Public and Land-grant Universities.

Rowland, T. (2013). The knowledge quartet: The genesis and application of a framework for analysing mathematics teaching and deepening teachers' mathematics knowledge. *Sisyphus-Journal of Education, 1*(3), 15–43.

Zazkis, R., & Leikin, R. (2010). Advanced mathematical knowledge in teaching practice: Perceptions of secondary mathematics teachers. *Mathematical Thinking and Learning, 12*, 263–281.

Program Recruitment and Retention (PR²)

Dana Pomykal Franz, Mississippi State University, df76@colled.msstate.edu
Diane Barrett, University of Hawai'i at Hilo, barrett9@hawaii.edu

Problem Addressed & General Approach

State of Recruitment and Retention

Teacher shortages across the nation are well documented. The American Association for Employment in Education (2020) specifically cites "mathematics teacher" as one of the top five critical shortage areas, with physics, chemistry and specific categories of special education only slightly ahead of mathematics. Colleges and universities across the nation report decreasing enrollment in colleges of education. Yet, a survey of students in science, technology, engineering, and mathematics (STEM) programs show nearly half of all STEM majors have an interest in teaching. It is imperative that mathematics teacher educators begin to understand how to better recruit and retain students in mathematics education majors.

Of equal importance is recruiting candidates who will positively impact K–12 education across the nation. Current national standards and guiding principles emphasize the need for recruitment of diverse prospective teachers that are academically high achieving. The Association of Mathematics Teacher Educators' (AMTE; 2017) *Standards for Preparing Teachers of Mathematics* states: "An effective mathematics teacher preparation program attracts, nurtures, and graduates high-quality teachers of mathematics who are representative of diverse communities" (Standard P.5, p. 26). The guiding principles set forth by the Mathematics Teacher Education Partnership (MTE-Partnership) highlights effective recruitment strategies, high admissions standards, support systems, and diversity of candidates as key in the recruitment of prospective teachers (2014). The National Council of Teachers of Mathematics (NCTM; 2020) emphasizes the need to make sure our new teachers are capable of preparing our grades 7–12 students for entrance into college.

Also of note is the increasing challenge to attract students of color into mathematics education. The demographics of teachers currently in the classroom do not match those of the nation's children; yet, there is significant evidence that students benefit from having teachers of color (D'Amico, Pawlewicz, Earley, & Mcgeehan, 2017). By 2024, students of color are expected to make up 56% of the student population, while the teaching force will remain primarily White. This statistic has changed very little in the years since 2000 (U.S. Department of Education, 2016). Retaining *all* prospective teachers is needed to increase the number of well-prepared secondary mathematics teachers. Continuing to find the best methods to retain across all prospective teachers is critical. These issues of recruitment and retention in secondary teacher education programs are pervasive across the United States.

Impact of Policy

There are a variety of ways in which teachers can attain licensure; however, for the remainder of this report we will be discussing programs that are delivered from universities. Darling-Hammond (2007) suggested the need for a paradigm shift in educational policy from the current top-down approach, which is one of designing controls to *develop capacity* that "enables schools and teachers to be responsible for student learning and responsive to diverse and changing student and community needs, interests, and concerns" (p. 363). Current educational policy requires teacher preparation programs to defend the effectiveness of their programs. Hence, current policy critiques traditional and alternative teacher preparation programs but are void of promoting recruitment and retention of teachers. Further, well-prepared teachers who come through comprehensive university programs are much more likely to stay in teaching than those who are prepared through alternative licensure programs (LPI, 2018). Advocacy is needed for policy changes for the secondary mathematics teaching profession, as well as for preparation programs, that will increase the number of well-prepared secondary mathematics teachers. The need for teachers who both represent the communities they serve and are retained in the profession is significant. Figure 1 shows the key decision points secondary mathematics teachers make in becoming and staying in the teaching profession. At many of these points, local, state, and national policies come into play that influence their decisions.

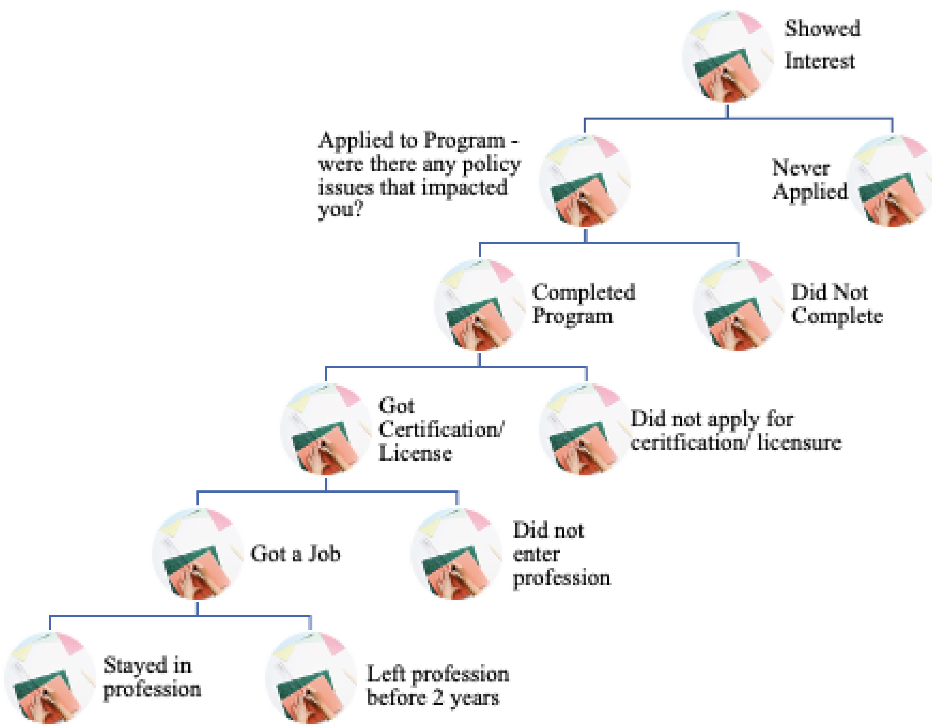

Figure 1. Decision Points of Secondary Mathematics Teachers.

Current Progress

The RAC is concurrently developing a white paper that captures the challenges and barriers of recruitment and program retention while preparing a Noyce Track 4 Submission for an August 2022 RFP. The goal of this white paper is to raise the awareness of how difficult it is to recruit students to secondary mathematics teacher education, much less to education or even to a traditional college or university. The Noyce grant submission aims to study how state and federal policy impact a program's ability to recruit and retain students. Our study will investigate four research questions: (1) What state, institution, or program policies lead to improved teacher candidate persistence and retention? (2) What state, institution, or program policies hinder teacher candidate persistence and retention? (3) What state, institution, or program policies negatively impact equity and diversity in programs? and (4) How do variance in these policies due to COVID-19 impact teacher candidate persistence and retention? It is our hope that this research will inform the field by highlighting the impact (both positively and negatively) that state, institutional, and program policy has on students. Further, we hope to leverage the relaxing of policies due to the COVID-19 pandemic to demonstrate that many of the current policies are overbearing and, potentially, not necessary. Our research methodology will include program-level case studies as well as policy analysis that highlight themes and trends in policy enactment.

Resources

The work of this RAC draws heavily on the work that is accomplished at our own institutions. Understanding how other institutions engage in recruitment has been very beneficial as we borrow and replicate ideas. For an outline of work at RAC member institutions, we encourage referencing Section IV: Opportunities for Recruitment and Retention in *The Mathematics Teacher Education Partnership: The Power of a Networked Improvement Community to Transform Secondary Mathematic Teacher Preparation* (Martin, Lawler, Lischka, & Smith, 2020).

Opportunities for Engagement

A small group of RAC members is working on a Noyce Track 4 submission. Members of the MTE-Partnership will have an opportunity to engage as a researcher if/when the RAC wins the grant. Information will be shared with members as the grant development and submission progresses.

Clinical Experiences

Marilyn E. Strutchens, Auburn University, strutme@auburn.edu
Jeremy Zelkowski, University of Alabama, jzelkowski@ua.edu
Belinda Edwards, Kennesaw State University, bedwards@kennesaw.edu
Basil Conway IV, Columbus State University, conway_basil@columbusstate.edu
Charmaine Mangram, University of Hawai'i at Mānoa, cmangram@hawaii.edu
Ruthmae Sears, University of South Florida, ruthmaesears@usf.edu
Jamalee (Jami) Stone, Black Hills State University, Jami.Stone@bhsu.edu (retired)
Charity Adams Cayton, East Carolina University, caytonc@ecu.edu

Problem Addressed & General Approach

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 rigorous state mathematics standards, and teachers are especially inexperienced with embedding the standards for mathematical practice (CCSS-M; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010) into their teaching of content standards daily. Further, many veteran teachers do not implement the mathematics teaching practices as discussed in *Principles to Actions: Ensuring Mathematical Success for All* (National Council of Teachers of Mathematics [NCTM], 2014) on an ongoing basis.
2. Bidirectional relationships between the teacher preparation programs and school partners in which clinical experiences take place are rare. Relationships that reflect a common vision and shared commitment to rigorous state standards and other issues related to mathematics teaching are lacking.

The work of the Clinical Experiences Research Action Cluster (CERAC) encompasses a number of the principles and principle indicators from the 2014 Mathematics Teacher Education Partnership's (MTE-Partnership) *Guiding Principles for Secondary Mathematics Teacher Preparation Programs*. CERAC emphasizes fostering partnerships between institutions of higher education, schools, and districts, as well as other stakeholders such as state departments of education, and focuses on preparing teacher candidates who promote student success in mathematics. Moreover, the 2017 Association of Mathematics Teacher Educators' *Standards for the Preparation of Teachers of Mathematics* (AMTE Standards) state:

> An effective mathematics teacher preparation program includes clinical experiences that are guided basis on a shared vision of high-quality mathematics instruction and have sufficient support structures and personnel to provide coherent, developmentally appropriate opportunities for candidates to teach and to learn from their own teaching and the teaching of others. (p. 26)

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 mathematics teaching 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 27 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 and researching to meet the goals that we set forth in our primary drivers and our aim statement. See Figure 1 for the CERAC's driver diagram. 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 its goals and objectives. Teams work together via conference calls, email, and the Canvas platform. They use Dropbox, Google Drive, and Canvas as ways of sharing files and materials. Additionally, they have held face-to-face meetings as a RAC that included breakout meetings for sub-RACs. The sub-RACS have overlap areas that drive and focus the RAC, such as the emphasis on the mathematics teaching practices (NCTM, 2014) and other equitable teaching practices, professional development for mentors related to the *Standards for Mathematical Practice* (National Governors Association & the Council of Chief State School Officers, 2010) and mentoring mathematics teacher candidates, and outcome measures. There are also specific goals to be attained within each of the sub-RACs, and each sub-RAC has developed its own specific research questions.

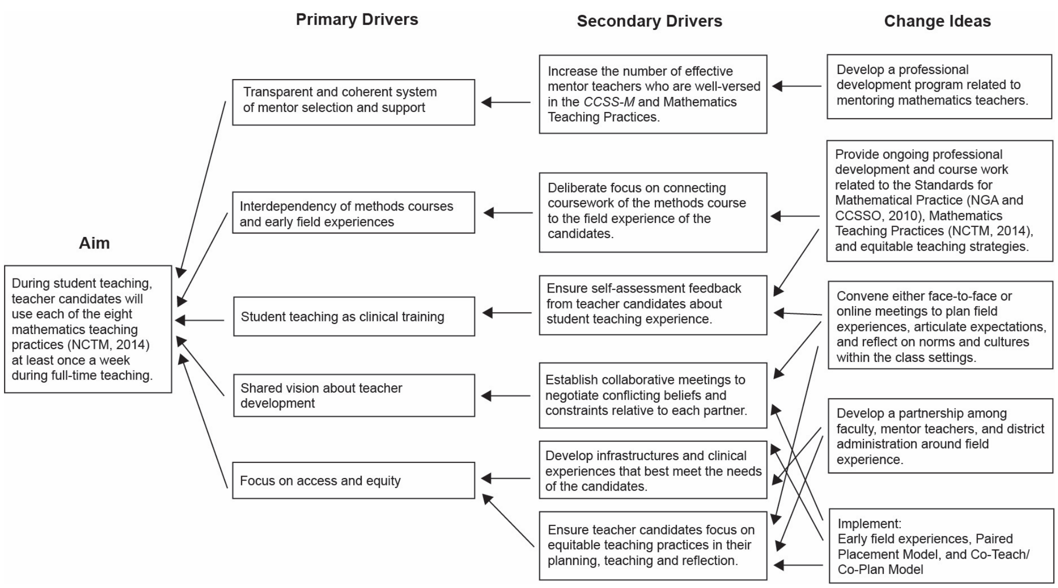

Figure 1. CERAC Driver Diagram

RAC Updates

Since the 2020 MTE-Partnership Conference, the CERAC has been busy implementing the work related to the National Science Foundation-IUSE grant, *Collaborative Research: Attaining Excellence in Secondary Mathematics Clinical Experiences with a Lens on Equity* (DUE-1726998, 1726853, 1726362). The project is led by principal investigators from Auburn University, the University of South Florida, and the Association of Public and Land-grant Universities (APLU). We are implementing an improvement science study to answer the following question: *How does a continuum of collaborative and student-focused clinical experiences, including co-planning /co-teaching and paired placement fieldwork models, impact pre-service teachers' equitable implementation of the Mathematics Teaching Practices (MTPs; NCTM, 2014) across multiple institutional contexts?* The research is being conducted by members of the three sub-RACs aforementioned.

Leaders of the sub-RACs, the project evaluator, and the hub leadership have been meeting monthly to ensure that the work of the sub-RACs continues to move forward along with the grant work. The annual report for the grant was submitted at the end of July and approved by the NSF program officer in August 2020. The program officer was impressed by how much we were able to accomplish amid the challenges of COVID-19 and noted the significance of the project's dissemination efforts, including the book chapters and recent presentations.

The 2020 MTE-Partnership Conference launched the MTEP 2.0 NIC, which changed the focus of the MTE-Partnership from teams working with RACs focusing on developing materials and protocols to implementing practices related to fostering the growth of teacher candidates to transforming programs. The CERAC is happy that many of its member teams are now also a part of the program transformation partnerships. We are also looking forward to sharing our work across the MTEP 2.0 teams.

Other highlights related to the RAC are that we convened a meeting of the leadership team and the advisory board members for the grant, participated in the MTE-Partnership pre-conference of the Association of Mathematics Teacher Educators' Annual Meeting in 2022, and members gave presentations during the AMTE Annual Meeting. During each of these events we had good participation and received critical feedback for our work. Finally, we provided an overview of our work during the MTEP 2.0 2021 virtual conference and had a work session for the RAC. Two of our grant advisory board members were present and provided helpful feedback and support for the work.

As follows are two presentations related to the CERAC as a whole:

1. Martin, W. G., & Strutchens, M. E. (2021, February 11-13, 18-20). *Mathematics pathways from high school to postsecondary: The role of mathematics teacher preparation* [Conference session]. Twenty-Fifth Annual Conference of the Association of Mathematics Teacher Educators (AMTE). https://amte.net/sites/amte.net/files/2021AMTEConf_Program_FINAL_02062021.pdf
2. Smith, W., Martin, W. G., Strutchens, M. E., Franz, D. P., & Uy, F. L. (2021, February 11-13, 18-20). The *Mathematics Teacher Education Partnership: Transforming secondary teacher preparation toward the AMTE Standards* [Conference session]. Twenty-Fifth Annual Conference of the Association of Mathematics Teacher Educators (AMTE). https://amte.net/sites/amte.net/files/2021AMTEConf_Program_FINAL_02062021.pdf

Methods SubRAC

Most of the methods sub-RAC work has focused on developing the following modules:

- *Standards for Mathematical Practice (SMP) Module.* The SMP Module is designed to provide teacher candidates and mentor teachers a bidirectional, shared experience to better understand the SMPs and their relevance to impactful teaching. This module is fully completed and available for use.
- *Lesson Planning (LP) Module for SMP & MTPs*. The LP Module is designed to discover teacher candidates' preconceived beliefs about lesson planning and move them toward a greater understanding of the components of high-quality lesson plans embedded in the Mathematics Teaching Practices (MTPs) designed to engage students in the Standards for Mathematical Practice. This module is fully completed and available for use.
- *Student Feedback (FB) to Improve Mathematical Goals.* The Feedback Module is designed to provide teacher candidates with opportunities to develop knowledge in effective practices for providing student feedback that is constructive, critical, and equitable. The focus is on learning to provide rich and appropriate feedback to students based on the mathematical goals of the lesson/activity. This module is fully completed and available for use.
- *Mathematical Task Writing (TW)*. The Task Writing Module is built around a mathematical letter writing exchange between middle and secondary teacher candidates and high school math students. Teacher candidates seem to better understand mathematics and are better able to understand their pen pals'

interests, attitudes, and learning progression. This module is nearing a phase of sharing beyond the development team.

From June 2020 to June 2021, the methods sub-RAC worked on multiple facets. These include:

1. Getting the SMP and LP modules in copy-ready upload to Canvas for users (posted).
2. Submitting the SMP and LP modules to the AMTE Supplemental Materials review (accepted).
3. Getting the FB module posted in Canvas (posted).
4. Starting the TW module materials/instructions (under construction).
5. Finishing a book chapter for a May 2021 submission. [The following book chapter was written throughout the spring 2021 semester and was submitted and notified of acceptance:

Zelkowski, J., Yow, J., Waller, P., Edwards, B.P., Anthony, H.G., Campbell, T.G., Keefe, A., & Wilson, C. (In Press). Linking the field-based mentor teacher to university coursework: Methods course modules for completing the triad of learning for mathematics teacher candidates. In Polly, D. (Ed.). *Preparing quality teachers: Advances in clinical practice* (pp. TBD). Information Age Publishing.]

6. Updating periodically, our CERAC methods website: https://ceracmethods.ua.edu/

As follows are presentations given by members of the methods sub-RAC:

1. Waller, P. P. (2021, February 11-13, 18-20). *Connecting lesson planning to practice: Engaging mentor teachers in productive interactions with teacher candidates* [Conference session]. Twenty-Fifth Annual Conference of the Association of Mathematics Teacher Educators (AMTE). https://amte.net/sites/amte.net/files/2021AMTEConf_Program_FINAL_02062021.pdf
2. Zelkowski, J. (2021, February 11-13, 18-20). *Transforming math teacher preparation program design for successful teacher candidate licensure examinations* [Conference session]. Twenty-Fifth Annual Conference of the Association of Mathematics Teacher Educators (AMTE). https://amte.net/sites/amte.net/files/2021AMTEConf_Program_FINAL_02062021.pdf

Paired Placement SubRAC

In 2020–2021, members of the paired placement sub-RAC were highly productive. Members of the paired placement sub-RAC met monthly to discuss implementing the model, data collection, and data analysis. Leaders of the sub-RAC participated in CERAC leadership meetings monthly and the CERAC Annual Advisory Board Meeting virtually. In addition, members of the sub-RAC presented at several local and national conferences. In 2020, members of the paired placement shared work through a presentation on *Fostering Competent, Collaborative, Reflective, and Caring Beginning Mathematics Teachers* via paired placements at the annual MTE-Partnership Conference. In addition, the CERAC leader, Marilyn Strutchens, gave a presentation to paired placement pre-service teachers, mentors, and faculty members at Columbus State University that focused on research related to inequities and micromessages that may take place during clinical experiences and mathematics teaching. She also showed how to combat these negative practices with equitable teaching strategies.

Furthermore, Charity Cayton and Maureen Grady, members of the co-planning and co-teaching sub-RAC, prepared and implemented workshops for members, mentor teachers, and pre-service teachers of the paired placement sub-RAC virtually at Columbus State University and the University of Hawai'i at Mānoa to support collaboration and the implementation of the model in 2021.

Additionally, members of the paired placement sub-RAC continued to implement the model and related data collection instruments for their NSF grant. Members facilitated orientation sessions and workshops for teacher candidates and mentor teachers, updated syllabi based on previous PDSA cycles, and revised other resources for implementation of the model. To further disseminate the model and encourage broader use of the paired placement model by other teacher educators, the paired placement team has continued to update the living document (https://sites.google.com/view/thepairedplacement/), which is the paired placement website. The site provides information about the model, how to implement the model, research on the model, tools for implementation, and tips for successful implementation for mentors, supervisors, and candidates. In 2020–2021, resources were branded with both NSF and MTE-Partnership logos to allow for further and larger dissemination.

In addition, in 2020–2021, the paired placement team conducted local PDSA cycles and collected data to answer questions relative to partnering with regional schools, co-teaching and co-planning, recruitment, retention, and the observational task protocols. These PDSA cycles have allowed members of the paired placement sub-RAC to analyze the intersection of the model with program improvement frameworks. Members of the paired placement sub-RAC used data from previous years to submit a new chapter that analyzed the effects of the implementation of the paired placement model on equitable teaching practices, mentor teachers, program improvement, and program completers:

Strutchens, M., Conway, B., Mangram, C., Erickson, D. & Ratliff, B. (In press). Implementing the paired placement model: Foregrounding the impact on key stakeholders. In D. Polly, R. W. Burns, E. Garin, & B. Badiali (Eds.), *Preparing quality teachers: Advances in clinical practice*. Information Age Publishing.

Below are other published works by members of the group.

1. Conway IV, B. (2021). An opportunity for the tracked. *School Science and Mathematics*, *121*(3), 175–186. https://doi.org/10.1111/ssm.12459
2. Dacia, S. L., Brooks, S., Conway, B. M., & Nguyen, H. (2021). Teaching statistics for social justice—An autoethnographic research report. *Georgia Educational Researcher*, *18*(1), 48–71. https://doi.org/10.20429/ger.2021.180103

Sub-RAC members have worked to merge broader clinical experiences RAC work into their courses. At Columbus State University, the noticing protocol provided by one of the advisory board members was used to strengthen its program toward becoming more equitable and strengthened the teacher candidates' use of the mathematics teaching practices during their clinical experiences. Some institutions have implemented modules as they fit into their own contexts. Tools from the co-planning/co-teaching modules have also been used during methods courses and internship to promote collaboration and increase the success of the paired placement model.

Co-planning and Co-teaching SubRAC

The co-planning and co-teaching (CPCT) suc-RAC consists of faculty and staff from the University of South Florida, Georgia State University, Black Hills State University, East Carolina University, and Chico State University. The goal of the CPCT sub-RAC is to educate collaborative pairs (teacher candidates and collaborating teachers) on how various co-planning and co-teaching strategies can support equitable learning opportunities and support the Mathematics Teaching Practices (MTPs). The following co-teaching strategies were used: one teach, one observe; station teaching; one teach, one assist; parallel teaching; team teaching; and alternative teaching. The co-planning strategies used were: one plans, one assists; one reflects, one plans; partner planning; one plans, one reacts; team planning; and parallel planning.

During 2020–2021, the team worked collaboratively to achieve the project goals. Monthly meetings were held virtually to discuss data collection, dissemination, and application of CPCT strategies in multi-faceted teaching contexts (e.g., virtual & hybrid) due to the COVID-19 pandemic. Also, a representative of the sub-RAC participated in monthly CERAC Leadership meetings and the Clinical Experiences Research Action Cluster (CERAC) advisory board meeting that was held in October 2020. The group participated in networking initiatives, facilitated professional learning opportunities, engaged in scholarly dissemination of work via conferences and journal submissions, and collected data from multiple institutions. Unlike past years where the CPCT sub-RAC has hosted live professional-development training events, this year sub-RAC members managed their professional development needs locally at each institution, which was primarily facilitated virtually due to COVID-19 restrictions. Cayton and Grady also facilitated virtual professional learning opportunities for Columbus State University and University of Hawai'i at Mānoa.

Moreover, members of the sub-RAC produced a plan for creating vignettes of professional development videos. The CPCT team members at East Carolina University (Cayton and Grady) began storyboarding training videos that will be translated into vignettes. Raw video footage of the professional development training recorded in September 2019 at the University of South Florida will be used to create the videos. This training included pre-service teachers and collaborating teachers and will provide material for each of the CPCT strategies. The goal is to produce shorter 3- to 5-minute video vignettes of the CPCT training to make the CPCT training more accessible to a wider audience. ECU has been provided funding to support a student to assist in video editing, and these videos will become part of a CPCT website to be created during the 2021–2022 academic year.

As a result of COVID-19, the group acknowledges the impact of the pandemic on the sustainability of CPCT change ideas during the educational disruption and the need to adapt implementation of CPCT strategies to include a variety of classroom delivery contexts (e.g., face-to-face, virtual, hybrid) and will work to include lessons learned as part of sub-RAC work during the 2021–2022 academic year. In addition, members published or presented the following works:

1. Sears, R., Zelkowski, J., Edwards, B., & Castro-Minnehan, C. (2020). Developing infrastructure to support teacher candidates during emergency remote clinical experiences. *AMTE Connections*, *30*(2). Retrieved from: https://amte.net/connections/2020/11/connections-thematic-articles-voices-field
2. Sears, R. (2020, September 30-October 2, 2020). *Unpacking the complexities of facilitating secondary mathematics clinical experiences in an online setting: Policies, practices, and challenges.* Keynote speaker for the Florida Distance Learning Association and Florida Association of Mathematics Teacher Educators.
3. Castro-Minnehan, C., & Sears, R. (2020, October 22). *Preservice teacher perspectives of their collaborating teachers' role in co-teaching during early field experiences.* Presentation at the National Association of Co-teaching (NACT). Virtual.
4. Sears, R., Pinder, C., & Castro-Minnehan (2020, November 11-14). *It takes two: Using co-planning and co-teaching to support equitable learning opportunities*. Presented at NCTM Regional Meeting (Virtual).
5. Sears, R., Stone, J., Junor-Clarke, P., Castro-Minnehan, C., Oloff-Lewis, J., & Grady, M. (2021, February 18). *Using co-planning and co-teaching during secondary mathematics clinical experiences to facilitate equitable opportunities.* Presentation at the Association of Mathematics Teacher Educators Conference. Virtual.
6. Cayton, C., & Grady, M. (2021, March 15). *Co-planning and co-teaching.* Presentation at Symposium for Columbus State Noyce Scholars.

7. Castro-Minnehan, C., & Sears, R. (2021, March 18). *Virtual K–12 school field experiences (VSFE): A review of the literature.* Presentation at the American Educational Research Association Conference. Virtual.

References

Association of Mathematics Teacher Educators (2017). *Standards for preparing teachers of mathematics*. Author.

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.

Gleason, J., Livers, S. D., & Zelkowski, J. (2017). Mathematics Classroom Observation Protocol for Practices ($MCOP^2$): Validity and reliability. *Investigations in Mathematical Learning, 9*(3), 111–129.

Martin, W. G., Lischka, A. E., Smith, W. M., & Lawler, B. R. (Eds.) (2020). *The Mathematics Teacher Education Partnership: The power of a networked improvement community to transform secondary mathematics teacher preparation*. Volume 4 in B. Benken (Ed.), Association of Mathematics Teacher Educators Professional Book Series. Information Age Publishing.

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

National Governors Association Center for Best Practices and the Council of Chief State School Officers (CCSSO). (2010). *Common core state standards*. Author. https://www.corestandards.org

Brief Reports

The Cooperative Collaborative of Columbus (C^3)

Peter Anderson, Columbus Regional Mathematics Collaborative, anderson_peter2@columbusstate.edu
Basil Conway IV, Columbus State University, conway_basil@columbusstate.edu

Introduction to C^3

In 2020, the Cooperative Collaborative of Columbus (C^3) formed under the guidance of the Mathematics Teacher Education Partnership (MTE-Partnership). C^3 is a partnership between the Muscogee County School District (MCSD) teachers and principals, the Columbus Regional Mathematics Collaborative (CRMC), and Columbus State University (CSU). Though similar to other NICs in the MTE-Partnership, C^3 is unique in its three-prong approach, outlined in Figure 1, to improving mathematics education in midwest Georgia or the Chattahoochee area. The three-pronged membership of C^3 seeks to recruit and train future teachers from the MCSD at CSU and support these teachers after initial certification through CSU graduate school and the CRMC. Given the unique membership of C^3, it is important to highlight how this partnership supports and interacts with one another.

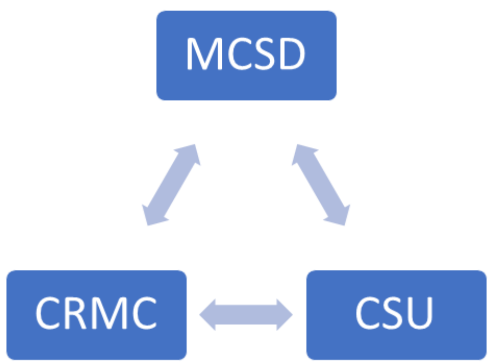

Figure 1. A three-pronged approach to improvement.

Columbus State University

CSU brings a broad level of support to the C^3, drawing membership from the dean and the mathematics education program in the College of Education and Health Professions (CoEHP), the mathematics department in the College of Arts and Sciences, and the Uteach program. This broad university platform is building a seamless teacher education experience for teacher candidates. In addition, the program is using a Noyce grant from the National Science Foundation to recruit new teachers into the program and provide financial assistance, professional development, and support, well into the second year of their professional careers.

Columbus Regional Mathematics Collaborative

The CRMC is a center of excellence that works closely with the CoEHP at CSU. It provides professional support in mathematics education to in-service and pre-service teachers in the greater Columbus area. It encourages teacher networking and collaboration. With resource teachers at the elementary, middle, and high school levels, its resources provide a broad spectrum of support to teachers. Specifically, the CRMC conducts a wide variety of professional development sessions, works with teachers directly in their schools, and provides curricular and pedagogical collaboration that supports the growth of teacher leaders in mathematics education. This past year the CRMC provided 86 virtual sessions with an average attendance of nine teachers per session. These sessions helped develop skills necessary for the transition to virtual learning. In these sessions the CRMC also solicited feedback for perceived needs and interest in future networking opportunities for teachers.

Muscogee County School District

The MCSD is a large and diverse district with a strong commitment to providing the best mathematics educational experience for its students. The MCSD members represent administration, middle, and high school teachers. Dacia Irwin and Jose Rodriguez worked to create a symposium to help build relationships with teachers in the district. Andrew Smith, Rodriguez, and Irwin were tasked to initially contact a community of mathematics teachers to combine with the members' MCSD math support teams. This pandemic year made these initiatives difficult to implement with increased responsibilities and limited face-to-face opportunities.

With CSU's focus on recruiting, developing, and supporting new teachers, the CRMC's focus on developing and retaining teacher leaders through networking and collaboration, and MCSD's commitment to providing teachers with the resources needed to provide quality outcomes in mathematics, C^3 is uniquely situated to build on one another's strengths and needs.

As a byproduct of the strong partnership between CSU and MCSD, the two announced a job-guarantee program in which any graduate of a CSU education program is guaranteed a teaching position in MCSD (Jones, 2019). In 2018, Go2Teach was formed as a way to "grow your own" teachers from the secondary setting. MCSD provides an elective course for high school students interested in pursuing a career in teaching. Students participating in the course and interested in pursuing a career further, attend CSU and may participate in teaching competitions at the university.

High school students interested in exploring education as a profession are paired with CSU education representatives who communicate with these individuals and help guide them through planned activities such as senior night and full campus visits. They prepare for future teaching experiences by taking part in meaningful pre-teaching activities. Initial credit is also awarded to students moving from the high school course to the education program at CSU.

Aim and Goals of C^3

The aim of C^3 is that by July of 2022 Columbus State University, the Columbus Regional Mathematics Collaborative, and the Muscogee County School District will align goals for mathematic education toward:

- the use of Mathematical Teaching Practices (NCTM 2014),
- purposeful engagement of the mathematical practice standards (NGA, 2010), and
- awareness and use of the five equitable teaching practices (Aguirre et al., 2013).

Considering educators' unfettered access to resources and the huge investment that school systems make in curricular programs, we must work to support the broad implementation of these goals to maintain consistent quality mathematics instruction. Educators know that "the implementation of a 'high-quality' curriculum—one that is aligned to rigorous state standards—leads to notable learning gains for students" (Chingos et al., 2012).

If schools and systems adopt a solid curriculum, there are still hurdles to overcome. A recent survey found that nearly one in four teachers use the textbook for all instruction, including lessons, activities, practice, and homework. Yet, they receive little support in presenting mathematics effectively (Kane et al., 2019). Understanding, using, and supporting teachers as they engage students in quality mathematics instruction is a vital component of student success.

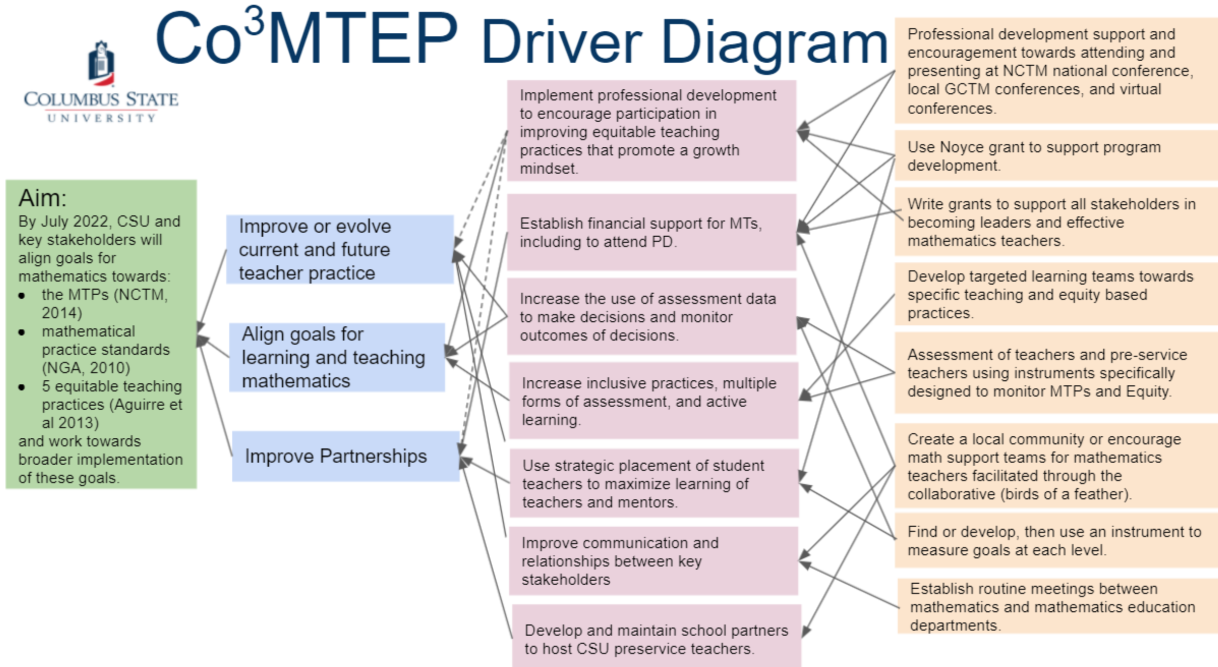

Figure 2. C^3 Driver Diagram

The C^3 program focuses on issues unique to the environment in the Columbus area. CSU is a university that provides many of the teachers who are employed by MCSD. By one estimate, nearly 70% of the teachers in the MCSD have at least one degree from CSU. The CRMC also assists both pre-service and in-service teachers, giving it a broad outreach. The driver diagram in Figure 2 outlines an effort that seeks to align the work of each of these entities into a more coherent force for mathematics education in Columbus.

Improving teacher practice cannot wait, so efforts are made to address them in the CoEHP at CSU through the use of instruction, practice, and reflection, all grounded in the Mathematics Teaching Practices (MTPs) and the Five Equitable Teaching Practices. In-service teachers benefit from professional development that involves best practices, with attention paid to equitable practices and growth mindset. In order to improve teacher practices, there needs to be support for the teachers in time and in compensation for professional development.

The primary driver for aligning goals for learning and teaching directs the use of assessment data to make and monitor decision outcomes. It calls for an increase in attention to inclusive practices and active learning models. Teacher candidate and professional development that is grounded in the MTPs is emphasized in this NIC.

None of the work that is done can be sustained without strong partnerships. There is a need for good mentors for young teachers. This community can be built when the MCSD and CSU are aligned in their commitment to high-quality math education. Communication is the foundation of the alignment. When the alignment of purpose and communication is strong t,hen partnerships can be developed and maintained for school to host CSU pre-service teachers.

Progress and Activities of C^3

In 2020–2021, much work was done through the determination and devotion to the educators in C^3. As follows are some of the activities.

Improve and Evolve Current and Future Teacher Practices

The CRMC presented a regular schedule of virtual workshops supporting the math teacher practices and the eight mathematical practices. Attendance at these workshops were sporadic, but on a regular basis they reached six teachers per session. In these sessions, teachers were actively engaged using the methodology supporting the teacher math practices and using the eight mathematical practices. Reviews were overwhelmingly positive, and many teachers expressed an interest in continuing with the session in the future.

Align Goals for Learning and Teaching Mathematics

The CoEHP at CSU developed the *Teaching and Mathematical Practices Indicators for Equity-Based Instruction* rubric with the guidance of Basil Conway. This "look for" rubric reflects MTPs but also includes the Five Equitable Teaching Practices. The intention is to increase inclusive practices, multiple forms of assessment, and active learning outcomes. Conway used the rubric with students in methods classes, allowing them to observe teachers on video. Students reflected on the teacher practices.

The "look for" rubric has evolved as an instrument through the use of Plan-Do-Study-Act (PDSA) cycles. In sessions involving MCSD teachers, where the use of the rubric was discussed, changes were suggested to allow for observers to focus on specific practices. The whole tool was thought to be overwhelming for new teachers observing lessons. The consensus of the group was that it was an invaluable tool for formation and reflection of equitable teaching practices. The instrument was revised to focus on only two elements at a time and include its intersection with the mathematical practice standards. The current instrument provides space for students to identify characteristics of teachers using MTPs and students implementing the mathematical practice standards, along with a space for detailed notes for justification.

The CoEHP and the mathematics department scheduled regular meetings beginning in October of 2020 and continuing monthly until March 2021. These meetings were to align programs and course schedules to support teacher candidates. These meetings have led toward the inclusion of more project-based learning cycles in mathematics classes, with a new focus on how assessment may be used to guide student learning.

Improved Partnerships

A major goal for C^3 is to improve partnerships. In October of 2020, MCSD participants Dacia Irwin and Luis Ruiz invited a speaker to a gathering of math teachers and CSU mathematicians to begin to build relationships and a connection to the goals of the C^3. As the CRMC provided over 60 virtual sessions, teachers were surveyed about involvement in a local mathematics teacher organization. Thirty-eight teachers expressed an interest in starting a community of mathematics teachers.

The CoEHP at CSU is committed to increasing the number of teacher mentors available to teacher candidates; the Noyce grant plays an important role in this by providing support for the teacher mentors. This grant allowed for three different presentations that focused on the aims of C^3. Marilyn Strutchens provided a session on practices that relate to enacting equity in the classroom; Maureen Grady and Charity Cayton provided routes to improving collaboration with mentors and teacher candidates through co-planning and co-teaching strategies; and John Staley, Brian Lawler, and Basil Conway focused on the use of mathematics lessons to explore, understand, and respond to social injustice in the classroom.

In the coming year the C^3 will continue the work of creating an Equitable Teaching Practices and Impact on Students Survey that was started this past fall using the PDSA cycle. Teacher candidates will use this to observe and reflect on teaching practices during their methods courses. These researchers might consider how this instrument might be used in a larger context with MCSD and other training with the CRMC. The instrument may also be expanded for use in some of the components in student teaching or internship. Teacher leaders from C^3 are looking to begin a local affiliate of NCTM to help in building a local community of teachers to support the mission of C^3. Teachers from the NIC are working to begin an initial virtual session in Fall 2021 and a joint conference with East Alabama Council of Teachers of Mathematics in Spring 2022. The NIC will continue to work with the mathematics department at the university to see how mathematics classes might work as a pump to mathematics education rather than a sieve keeping students out. The CRMC will work with the CSU and MCSD to create "birds of a feather" groups where teachers with similar interests can support and collaborate with one another. Zoom-like applications make this much more accessible.

In the MCSD, it's important to be aware of how the efforts of the NIC can support the personalized learning initiative from the district. The district is moving ahead in a one-to-one Chromebook initiative, to put in the hands of every student technology and access points for the community. Supporting teachers to understand what research-based practices that foster student learning from personalized learning is on the radar for C^3.

C^3 will keep the program's drivers at the center of its efforts. The aim is to improve mathematics instruction and learning through the alignment of best teaching and learning practices; thus, the group needs to stay focused and adapt by using flexibility. Focusing on the primary and secondary drivers will allow C^3 to shift its action plans to monitor and achieve its primary goals.

References

Aguirre, J. M., Mayfield-Ingram, K., & Martin, D. B. (2013). Know thyself: What shapes mathematics teacher identities? In *The impact of identity in K–8 mathematics learning and teaching: Rethinking equity-based practices*. National Council of Teachers of Mathematics.

Blazar, D., Heller, B., Kane, T., Polikoff, M., Staiger, D., Carrell, S., & Kurlaender, M. (2019). *Learning by the book: Comparing math achievement growth by textbook in six Common Core states*. Center for Education Policy Research, Harvard University.

Chingos, M. M., & Whitehurst, G. J. (2012). *Choosing blindly: Instructional materials, teacher effectiveness, and the Common Core*. Brookings Institution.

National Governors Association Center for Best Practices and the Council of Chief State School Officers (CCSSO). (2010). *Common core state standards*. Author. https://www.corestandards.org

Jones, A. (January 2019). *CSU and MCSD announce new job guarantee partnership*. Retrieved from https://www.wtvm.com/2019/01/14/csu-mcsd-announce-new-job-guarantee-partnership/

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

The Middle Tennessee Mathematics Teacher Education Partnership: Gaining Momentum Across Partners

Alyson E. Lischka, Middle Tennessee State University, Alyson.Lischka@mtsu.edu
Robin Bollman, Middle Tennessee State University, Robin.Bollman@mtsu.edu

The Middle Tennessee Mathematics Teacher Education Partnership (MT-MTEP) is a partnership among two universities and their school and Center partners. Middle Tennessee State University (MTSU), a founding member of the Mathematics Teacher Education Partnership (MTE-Partnership), originated the MT-MTEP with Rutherford County Schools and the Tennessee Stem Education Center (TSEC). In 2018, Tennessee Technological University (TTU) joined the MT-MTEP, expanding the partnership to a regional focus and broadening the work of transformation in Middle Tennessee.

Similar to many mathematics teacher preparation programs across the nation, MT-MTEP has a focus on teacher recruitment and retention, with particular attention to increasing diversity among teacher candidates, in order to address the falling numbers of teachers in our programs. Its Networked Improvement Community (NIC) had made prior progress on establishing relationships among stakeholders, implementing recruiting strategies, and redesigning content courses. With this foundation, the group moved into more earnest discussions about diversity and equity in its programs as it recognized the lack of diversity among its candidates and issues related to equity within the programs. Even though the 2020–2021 academic year brought challenges, MT-MTEP gained momentum in addressing this goal. In this report, the researchers share both successes and struggles on their journey to grow and improve their work with the preparation of secondary mathematics teachers.

Aims and Driver Diagram

The June 2020 MTE-Partnership Conference provided the Middle Tennessee NIC an opportunity to reframe its goals and turn its focus toward issues of diversity and equity. Through discussion of the root cause analysis activity, the group arrived at the following statement:

> The underlying problem we will address is twofold and broadly stated as recruitment and diversity. We see these as intertwined problems as we work to increase the diversity in our student population as a piece of increasing overall enrollment through creating a more inclusive program across all aspects of teacher preparation. (MT-MTEP MTEP 2.0 Application)

Building from here, they viewed the work of attending to this underlying problem as long-term work rather than short-term. In their view, a goal focused on diversity and inclusion requires close attention to culture and relationships within programs and is something that requires time to shift. Taking these ideas into account led them to the aim:

> By 2025, the Middle Tennessee Partnership will increase efforts related to the equitable teaching of mathematics to better align with AMTE Standards and improve recruitment strategies for secondary education mathematics (6-12 licensure) to (a) increase the number of students majoring in secondary mathematics education by 50%, and (b) increase the number of secondary mathematics education majors from diverse backgrounds so as to be more aligned with the local student demographics. (MT-MTEP MTEP 2.0 Application)

Because this NIC is working across two programs with slightly different demographics, it was important to draft goals that were reasonable and would accurately reflect growth. The aims, drivers, and change ideas developed at the June 2020 MTE-Partnership Conference are displayed in Figure 1.

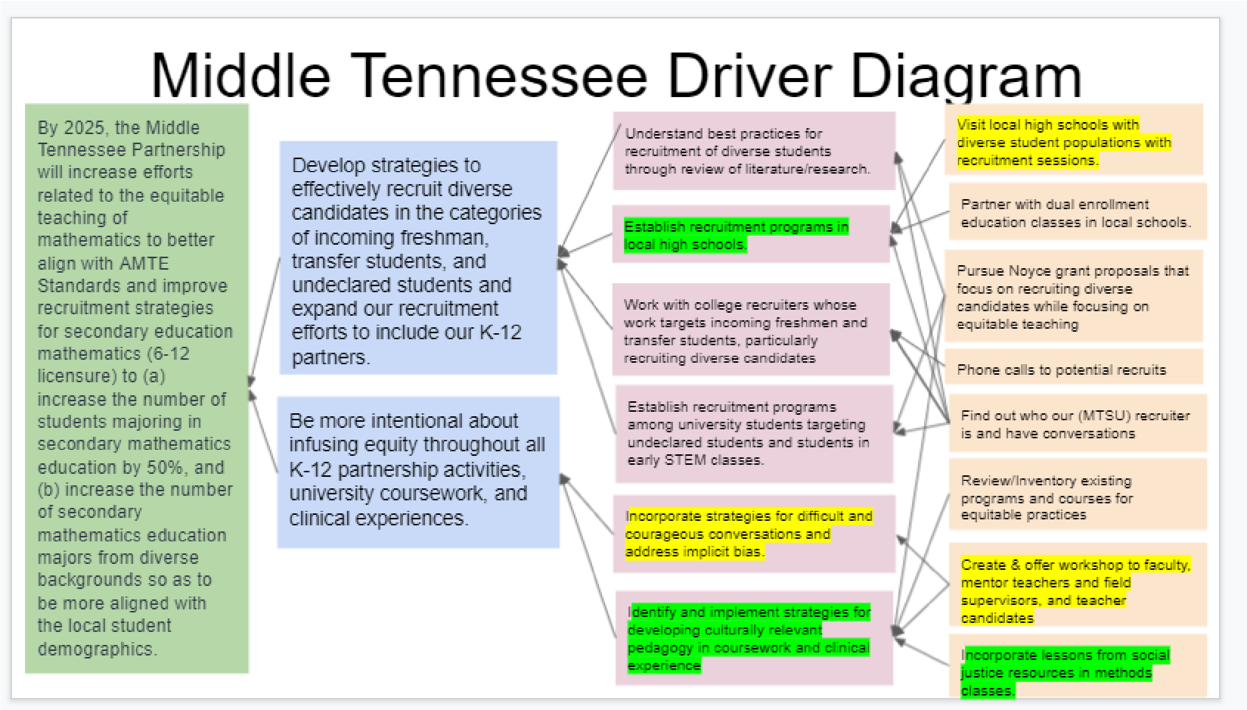

Figure 1. MT-MTEP Driver Diagram.

Note: The green box is the aim, blue boxes are the primary drivers, purple boxes are secondary drivers, and pink boxes are change ideas. Highlighted statements indicate change ideas and secondary drivers for which progress has been made or initiated in 2020–2021.

Successes and Struggles: Gaining Momentum Toward the Aim

The 2020–2021 academic year (i.e., COVID-year) brought both successes and struggles in moving toward the NIC's goals through implementation of strategies included in its change ideas. Here are highlighted some of the strategies (with both successes and struggles) and a glimpse of the multi-faceted way in which they are moving their programs closer to the aim—and closer to alignment with the *Standards for the Preparation of Teachers of Mathematics* (Association of Mathematics Teacher Educators, 2017) and *MTEP Guiding Principles* (MTEP, 2014).

Social Justice Lesson Sequence in Mathematics Methods

After identifying a need for activities focused on social justice and equity in methods courses, members of MT-MTEP involved in mathematics methods instruction developed a sequence of activities focused on teaching mathematics for social justice to be implemented in secondary methods courses. One member drafted the sequence and then other members reviewed and provided feedback, which was recorded in the first Plan-Do-Study-Act (PDSA) cycle for this initiative. The sequence includes readings to orient teacher candidates to the role of mathematics teaching in conversations about equity and inclusion (e.g., National Council of Teachers of Mathematics [NCTM], 2014, 2018; Spencer & Hand, 2015). The activity sequence also includes opportunities for teacher candidates to examine their own biases through a Multi-Cultural Mathematics Dispositions Survey (White et al., 2012), and to practice writing and enacting mathematics lessons to explore social justice (Berry et al., 2020). Feedback collected in the study portion of the PDSA cycle revealed additional opportunities and aspects to include in the activity sequence, which were added prior to the initial implementation.

Following the drafting of the lesson sequence, the sequence was implemented once at each institution in MT-MTEP, MTSU and TTU, in Fall 2020 and Spring 2021, respectively. Each implementation was accompanied by its own PDSA cycle to gather data on the implementation. Data collection in the Fall 2021 implementation at MTSU was slightly hampered by COVID restrictions and adjustments to account for quarantines during the semester. Despite these struggles, data indicated that prospective teachers who engaged with these activities were inclined to use social justice topics in teaching following the activities and felt they had more tools with which to engage their own students in difficult conversations. Although not part of the data collection for this PDSA cycle, instructors at MTSU noted that at least two of the participating prospective teachers initiated social justice lessons with their students in teaching practica during Spring 2021, unprompted by any requirements to do so. Even with this success, instructors also noted the difficulty in engaging prospective teachers in conversations about social justice and equity and reflected on ways to improve this aspect of the sequence implementation.

In Spring 2021, the activity sequence was implemented at TTU with revisions that resulted from the first implementation PDSA cycle. A practitioner reading was added (Izard, 2018), and final reflective assignments were altered to fit the needs of the course structure. Although the sequence has been implemented, analysis of the study portion of the PDSA cycle is incomplete. Further reflection and revisions of this strategy will take place in Summer 2021 prior to a third implementation cycle in Fall 2021 at MTSU.

Developing Culturally Relevant Pedagogy in Coursework and Clinical Experience

The MT-MTEP's secondary driver "identify and implement strategies for developing culturally relevant pedagogy in coursework and clinical experiences" was the focus of two change ideas in the 2020–2021 academic year: teaching trios on equitable teaching strategies and de-tracking conversations in the partner school system. This rather large secondary driver is one that spans multiple spaces in teacher preparation, from education courses to mathematics content courses to experiences in schools. As such, the researchers are taking a multi-faceted approach to progress in this area.

Equitable Teaching Strategies in STEM Education Teaching Trios

Faculty across MTSU's College of Basic and Applied Sciences participated in a faculty learning community focused on inclusive teaching strategies in STEM courses. Two faculty in the mathematics department participated in this community, with the intent of bringing conversations about equitable teaching strategies to the foreground in the department in the future. The teaching trios structure included readings about equitable teaching in STEM disciplines, conversations about the readings and other experiences, observations of colleagues teaching with a focus on equitable teaching strategies, and development of observation protocol to support reflective discussion about teaching practice.

As in other work, there were both struggles and successes. The community began with three faculty members from the mathematics department but dropped to two when additional teaching requirements and responsibilities due to COVID restrictions became too much for the third member. However, the remaining two members engaged in fruitful discussion to make sense of ways in which other mathematics faculty might be open to discussions about equitable practice. A reflective teaching protocol that brings attention to equitable teaching practices was developed to be used at a later time with the whole department. In addition, the faculty members were able to use examples from observations of their own teaching to clarify particular practices in mathematics classrooms that can be inclusive, or not, of diverse learners. For example, the ways in which mathematics instructors use the ideas put forth by learners during a mathematical discussion can either serve to invite learners into the community or send the message that their ideas are not welcome. These discussions and observations have laid a foundation for bringing discussion of equitable teaching to attention in the 2021–2022 academic year, with the hope of eventually moving toward more culturally relevant pedagogy in content courses for all mathematics learners.

De-Tracking Conversations in Local Schools

Recognizing that systemic structures in schools can serve as barriers to equitable instruction for each and every student, the MT-MTEP school partner, Rutherford County Schools, initiated an equity committee in the school system with the support of MT-MTEP personnel. The committee includes representatives from every high school mathematics department as well as connections to administration and parent groups. Conversations of the equity committee centered on equity for students and advocating for each and every student, with a focus on tracking that currently exists within some schools in the system—and ways in which de-tracking might be accomplished. The researchers consider this activity as a change idea attending to multiple secondary drivers: incorporate strategies for difficult and courageous conversations, address implicit bias, and identify and implement strategies for developing culturally relevant pedagogy in coursework and clinical experiences. The activity of the committee is an effort to engage in difficult conversations about the role and benefits of tracking across all stakeholders. Beyond just discussion, the committee has made strides toward de-tracking in some schools. By partnering with and standing alongside our school system in this process, the MT-MTEP personnel are also ensuring that prospective teachers have classrooms in which they can participate in field experiences where culturally relevant pedagogy and equitable teaching strategies are the norm.

Work of the equity committee has progressed to include plans for four high schools within the system to engage in (or continue) some level of de-tracking in the 2021–2022 academic year, including one school which plans to completely de-track the freshman level mathematics course by only offering one level of Mathematics I (as opposed to the four levels offered in some schools). Plans for this school include rolling out the de-tracked courses by adding one grade level each year following the 2021–2022 school year. Drawing on connections and resources within MTEP, Rutherford County Schools will provide professional development, delivered by experts within the MTEP network, to the participating schools in Summer 2021. Experts are also consulting on data collection plans that will support the acceptance (and eventual growth) of this practice across the school system.

Each of these strategies lays the foundation for this NIC to work toward engaging in difficult conversations about equity and providing equitable teaching strategies across its preparation programs and in the area school.

Recruitment in Schools

With recruitment of students into these programs as a continual need, the MT MTEP worked to find new ways to recruit throughout this year. Although it had a variety of events and efforts already used to recruit on-campus students, this year the group wanted to reach a broader audience. In particular, they are working to find ways to go into area high schools to interact with students. Due to COVID, some of these plans were restricted or altered to accommodate health protocols. Even so, working with Rutherford County Schools, MTSU established a recruitment seminar for high school students and offered it in May 2021. In this first iteration, MTSU learned how to structure such a remote event, how to spread the word to connect with students, and how to invite alumni of the MT MTEP program to participate in this activity. Though participation was low, the researchers see great potential for ways in which such remote recruitment events might be carried out in the future, allowing the MT MTEP to recruit from a broader pool of students prior to their arrival on a university campus.

Future Goals

As our aim and driver diagram indicate, the MT MTEP is only completing the first year of work toward a five-year goal. There have been successes and struggles, but across all efforts the group is seeing the benefits and affordances that working as a local NIC can provide. This year, the NIC has been more active across multiple sites than ever before. Specific goals that the group has for the next year include continuation of the next iterations of strategies outlined in this report, along with efforts to build a community of practice among secondary teacher alumni and current students (which will be funded by a grant); collaboration between MTSU and TTU to engage prospective teachers in a poverty workshop (an experience-based activity that builds awareness of the culture of students living in poverty); and additional efforts to make connections with diversity and equity efforts on MTSU campuses to bolster the MT MTEP work. As the group learns to collaborate in more productive and fruitful ways, it hopes to see that progress correspond to growth and strengthening in both of the preparation programs and in the local school systems.

References

Association of Mathematics Teacher Educators. (2017). *Standards for preparing teachers of mathematics.* Author.

Berry, R. Q., Conway, B. M., Lawler, B. R., & Staley, J. W. (2020). *High school mathematics lessons to explore, understand, and respond to social injustice.* Corwin.

Izard, B. (2018). Teaching human rights through mathematics. *The Mathematics Teacher, 112*(2), 114–119.

Mathematics Teacher Education Partnership. (2014). *Guiding principles for secondary mathematics teacher preparation*. Association of Public and Land-grant Universities. Retrieved from https://www.aplu.org/projects-and-initiatives/stem-education/SMTI_Library/Updated-Guiding-Principles-for-Secondary-Mathematics-Teacher-Preparation-Programs/file

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

National Council of Teachers of Mathematics. (2018). *Catalyzing change in high school mathematics: Initiating critical conversations.* Author.

Spencer, J. A., & Hand, V. M. (2015). The racialization of mathematics education. In L. D. Drakeford (Ed.), *The Race controversy in American education* (pp. 237–258). Praeger.

White, D. Y., Murray, E. C., & Brunaud-Vega, V. (2012). Discovering multicultural mathematics dispositions. *Journal of Urban Mathematics Education, 5*(1), 31–43.

Maximizing Teacher Candidate Performances Based on Internal Program Measures: Program Design Considerations

Jeremy Zelkowski, The University of Alabama, jzelkowski@ua.edu
Tye G. Campbell, Crandall University, Tye.Campbell@crandallu.ca
Alesia Mickle Moldavan, Fordham University, amoldavan@fordham.edu
Jim Gleason, The University of Alabama, jgleason@ua.edu

Abstract

Using Structural Equation Modeling vis-à-vis path analysis, the authors tested models to understand the strength of relationships related to national recommendations of professional organizations and standards. The models explain much of the variance in Praxis-II and edTPA performances, respectively, with high power and medium to large effect statistics. This report provides implications for secondary mathematics teacher preparation with respect to the recommendations/standards of the multiple professional organizations. Program design and mathematics teacher preparation at local, state, and national levels should be of interest to readers.

Introduction

A national collaborative effort has focused on the transformation of secondary mathematics teacher preparation—the Mathematics Teacher Education Partnership (MTE-Partnership). Over 40 secondary mathematics teacher preparation programs (TPPs) in the United States began work in 2012 to create a framework with two goals: (a) establish a national research and development agenda and (b) produce well-prepared first-year mathematics teachers. While large-scale reform efforts, such as the work of the MTE-Partnership, that aim to evaluate TPPs with the intent to improve mathematics teacher preparation, critiques can be made for such efforts being costly, laborious, and lacking insufficient modeling with respect to measurement (Tatto, 2018).

The researchers recognize external critiques and examinations will continue to influence mathematics teacher education. Teacher candidates (TCs) ought to be well-prepared with a strong sense of self-efficacy and extensive knowledge from internal program measures to be easily ready for professional exams such as Praxis-II and edTPA.

Study Purpose

The purpose of this study was to examine how one secondary mathematics TPP design in the United States, in alignment with several professional organization recommendations and standards publications (e.g., Conference Board of the Mathematical Sciences' *Mathematics Education of Teachers (MET) II*, MTE-Partnership *Guiding Principles*, Association of Mathematics Teacher Educators' *Standards for Preparing Teachers of Mathematics*) demonstrates TCs' knowledge, skills, and teaching ability readiness as measured by internal measures and relationship to Praxis-II (Education Testing Service [ETS], 2020) and edTPA (Stanford Center for Assessment, Learning and Equity [SCALE], 2020) scores. The Conference Board of the Mathematical Sciences' (CBMS; 2012) MET II states: "Whatever the length of the program, the recommendations described here, particularly the 9-semester-hours of coursework designed for prospective teachers, are ambitious and will take years to achieve. They are, however, what is needed" (p. 55). Furthermore, the standards of the Association of Mathematics Teacher Educators (AMTE; 2017) states: "Effective programs preparing teachers of mathematics at the high school level provide candidates multiple opportunities to learn to teach mathematics effectively through the equivalent of three mathematics-specific methods courses" (p. 141). Both professional organizations acknowledge that most TPPs do not offer the recommended coursework and experiences to meet these recommendations, demonstrating the need for comprehensive reviews of program design efforts in correspondence with the targeted goals for the preparation of mathematics teachers.

The authors developed a framework for constructing Structural Equation Models, vis-à-vis path analyses, to examine the relationship of multiple mathematics content and sequenced methods courses for TCs, as well as various internal measures used as part of our program's voluntary participation in the CAEP NCTM SPA review. Tatto (2018) stated:

> Recent reviews of [mathematics] teacher education reveal the need for more systematic exploration of programs and their intended outcomes, and for rigorous research directed at producing system-level evidence of program effects. Indeed, national-, state-, or even program-level evaluations of teacher education program [design] effects are rare. When they have been undertaken, evaluations have not shed much light on the acquisition of knowledge needed for teaching because they have not measured future teachers' knowledge outcomes and have, for the most part, relied on responses to satisfaction surveys. (p. 410)

While Tatto's chapter utilized the international comparison data from the Teacher Education and Development Study in Mathematics (TEDS-M), Tatto suggested that program alignment with accreditation demands are much more likely to generate graduates who are highly knowledgeable and well-prepared beginning mathematics teachers. This work directly addresses Tatto's (2018) call. That is, these authors aimed to provide empirical evidence that examines program relationships to performance assessments (i.e., licensure exams). Appendix A presents a cross-sectional analysis of the aforementioned national documents in relation to the research brief, while Figure 1 presents the program design sequence and related internal program measures.

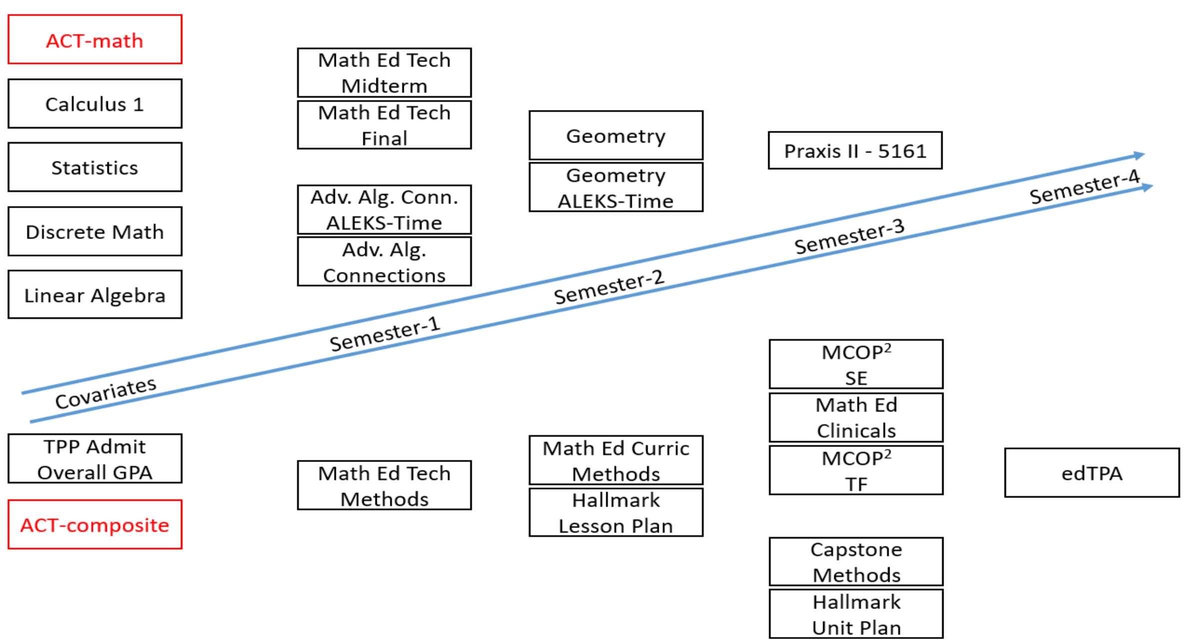

Figure 1. Sequential Program Design, Covariate Measures, and Common Measures.

Results

The path model explains 74.1% of the variance of Praxis-II exams and 49.2% of the variance in edTPA scores. For purposes of this research brief, we elaborate only the results of the full study in comparison to the work of the MTE-Partnership and national recommendations for secondary mathematics teacher preparation.

Discussions

Questions about National Recommendations

The CBMS MET II (2012) recommends mathematically, in addition to the 9 specialized credit hours in the long-sequence mathematics major, advanced calculus (analysis), introduction to proofs, abstract algebra, geometry or mathematical modeling, computer programming, two statistics courses, linear algebra, and a three-course calculus sequence. Findings from this report's analyses indicate that the *Specialized Content Knowledge* focus in the Advanced Algebraic Connections course to examine rings, groups, fields, and polynomials in relation to the high school curriculum and from a historical developmental approach could alleviate the need for abstract algebra, even analysis to some extent, as well as history of mathematics. Thus, the authors question whether the CBMS MET II long-sequence is well-beyond aspirational and beyond what is needed. Perhaps there should be a serious consideration of compromise between the long-sequence and short-sequence in how to integrate the pure mathematical major study within advanced perspective courses focused on *Specialized Content Knowledge* and *Horizon Content Knowledge* for teaching mathematics.

The AMTE Standards (2017) lack a direct focus on the developmental and pedagogical trajectory of TCs. That is, the sequencing of multiple methods courses likely has a greater impact than a single semester with multiple methods courses before student teaching—at least this study's findings suggest greater direct and indirect effects in relationship to higher edTPA performances.

A Validity Argument for Program Design

Considering the recommendations from multiple professional documents discussed herein, this report's path models and strength of the relationships of measures provide a strong case for beginning a validity argument for the program design presented. Bostic et al. (2019) and Krupa et al. (2019) presented summary chapters for validity of mathematics assessments of mathematical knowledge and frameworks for new directions in mathematics education predicated on the *Standards for Educational and Psychological Measurement in Education* (AERA, APA, & NCME, 2014). The authors define the path models as quantifiable tests for considering the validity of program design in relation to the recommended program experiences previously discussed in four nationally recognized publications. This report's analyses and models provide multiple sources of validity evidence. The validity argument on these works, as well as Kane (2001), is based upon considering the program model/design, the coursework, and the key assessment measures collectively within the path analyses of this study. Those four validity sources include (a) relationships between program measures and external measures, (b) evidence of consequences of TCs completing program experiences, (c) evidence of TCs' response processes on internal measures, and (d) validity evidence of program measures' test content.

Conclusion

Within the MTE-Partnership's Guiding Principles are high demands that differentiate the differences between a *well-prepared* beginning mathematics teacher and one who is *just-barely qualified.* Similarly, the AMTE Standards (2017) provide strong recommendations for developing *well-prepared* mathematics teachers in which we can endorse the recommendation of three methods courses, as well as that of advanced perspective mathematics courses (vis-à-vis the CBMS MET II). However, the authors acknowledge that no TPPs, state departments of education, or accreditation bodies in the U.S. of which we are aware currently require TPPs to consider the MTEP Guiding Principles, AMTE Standards (2017), and/or CBMS MET II recommendations, although some states require CAEP NCTM SPA accreditation. The hope is that this research brief can aid other TPPs in leveraging transformational change.

References

American Educational Research Association, American Psychological Association, & National Council on Measurement in Education. (2014). *Standards for Educational and Psychological Measurement in Education*. American Educational Research Association.

Association of Mathematics Teacher Educators. (2017). *Standards for preparing teachers of mathematics.* Author.

Conference Board of the Mathematical Sciences (CBMS). (2012). *The mathematical education of teachers II (MET II)*. American Mathematical Society and Mathematical Association of America.

Council for the Accreditation of Educator Preparation (CAEP). (2012). *The National Council of Teachers of Mathematics specialized professional association standards for mathematics teacher preparation.* Author.

Education Testing Service (ETS). (2020). *The Praxis passing scores by test and state.* https://www.ets.org/praxis/institutions/scores/passing/

Kane, M. T. (2001). Current concerns in validity theory. *Journal of Educational Measurement, 38*(4), 319–342.

Krupa, E., Bostic, J. & Shih, J. (2019). Validation in mathematics education: An introduction to quantitative measures of mathematical knowledge: Researching instruments and perspectives. In J. Bostic, E. Krupa, & J. Shih (Eds.), *Quantitative measures of mathematical knowledge: Researching instruments and perspectives* (pp. 1–13). Routledge.

Mathematics Teacher Education Partnership (MTEP). (2014). *Guiding principles for secondary mathematics teacher preparation programs.* Association of Public and Land-grant Universities.

Stanford Center for Assessment, Learning and Equity (SCALE). (2020). *Recommended professional performance standards.* https://www.edtpa.com/PageView.aspx?f=GEN_PerformanceStandard.html

Tatto, M. T. (2018). The mathematical education of secondary teachers. In M. T. Tatto, M. Rodriguez, W. Smith, M. Reckase, & K. Bankov (Eds.), *Explore the Mathematical Education of Teachers using TEDS-M Data* (pp. 409–450). Springer.

Appendix A.

Cross-Sectional Analysis of Recommendation and Standards Documents

	Mathematics Content	Mathematics Methods	Other Related to Study
CBMS MET II (2012)	A major in mathematics with at least: • Three-course calculus sequence • Intro to statistics • Intro linear algebra • **9 semester-hours focused on high school math from advanced standpoint** • 9 additional semester-hours ○ Introduction to Proof ○ Abstract Algebra ○ Additional course	High School Preparation • **Math methods courses (plural)** Middle School Preparation • **Two math methods courses** Preparation programs focused on both high school and middle school would need at least three given the plurality of both high school and middle school recommendations.	• Engage in **Standards for Mathematical Practice** within coursework as learners • **Use technology and tools strategically** during preparation • Experiences with reasoning and proof • Modeling rich real-world problems • Historical development of math
CAEP NCTM SPA (2012)	Standard 1: **TCs have knowledge of** major math concepts, algorithms, procedures, applications in varied contexts, and connections within and among mathematical domains of Number, Algebra, Geometry, Trigonometry, Statistics, Probability, Calculus, Discrete Mathematics Standard 2: **TCs** solve problems, represent mathematical ideas, reason, prove, use mathematical models, attend to precision, identify elements of structure, generalize…	Standard 3: TCs apply **knowledge of curriculum standards for mathematics** and their relationship to student learning within and across mathematical domains. **They incorporate research-based mathematical experiences and include multiple instructional strategies and mathematics-specific technological tools**… Standard 4: TCs exhibit knowledge of adolescent learning, development, and behavior. They use this knowledge to plan and create sequential learning opportunities grounded in mathematics education research where students are actively engaged in the mathematics…	Standard 5: TCs provide evidence demonstrating that as a result of their instruction, secondary students' conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and application of major mathematics concepts in varied contexts… Standard 6: **TCs Engage in continuous and collaborative learning that draws upon research in mathematics education** to inform practice…(6b) Standard 7: **TCs engage in a planned sequence** of field experiences and clinical practice under the supervision of experienced and highly qualified mathematics teachers…
MTEP GPs (2014)	In reference to the **CBMS MET II:** Mathematical habit of mind, knowledge of the discipline, specialized knowledge of mathematics for teaching, and the nature of mathematics.	TCs can design instruction, use instructional methods and strategies, assess and reflect, use technology well, attend to diverse student populations, and **engage in embedded early and sequential intense** clinical experiences with expert supervision.	**Commitments by institutions** of higher education with shared responsibility across the administration, faculty, and partner schools, as well as supporting **partnerships with disciplinary [mathematics] faculty** and [K-12] schools… Institutional focus exists and faculty are supported and rewarded for leadership in preparation programs…
AMTE SPTM (2017)	**High School:** Math major equivalency, including statistics, with **at least three content courses** relevant to teaching high school mathematics incorporating sufficient attention to a data-driven, simulation-based modeling approach to stats. **Middle School:** Alignment to the **CBMS MET II** (2012) and Statistical Education of Teachers (2015)	High School Preparation • **Three mathematics-specific methods courses** Middle School Preparation • **Coursework** focused specifically on teaching middle level mathematics…	**Clinical experiences in both high school and middle schools** in which TCs have support to develop teaching practices that support learning of conceptual knowledge and engagement by students in mathematical practices.

Research Papers

Prospective Secondary Mathematics Teachers' Expectancy and Value for Teaching Practices: Comparing Across Content Areas

Jeremy F. Strayer, Middle Tennessee State University, jeremy.strayer@mtsu.edu
Kingsley Adamoah, Middle Tennessee State University
Yvonne Lai, University of Nebraska–Lincoln, yvonnexlai@unl.edu

Abstract

There is increasing demand on secondary mathematics teachers to enact mathematically intensive core teaching practices that center instruction on student thinking in an increasingly diverse set of content areas. Expectancy-value theory suggests that if teachers have high expectancy and high value for enacting core practices, they are more likely to carry them out. This report examines how changes in expectancy and value for prospective secondary teachers who learn mathematics using MODULE(S^2) materials *compare* across algebra, geometry, modeling, and statistics courses and *correlate* with teaching practices enacted in the courses. One-hundred seventy-four prospective teachers participated in this study that found increases in expectancy and value across the board, with the largest practical significance in expectancy change occurring in modeling and statistics courses. We conclude that prospective teachers' past experience learning algebra and geometry and lack of experience with modeling and statistics likely contribute to the expectancy gains observed in this study. These results, paired with previous research showing MODULE(S^2) provides opportunities for prospective teachers to develop knowledge for mathematics teaching, suggests that MODULE(S^2) can serve as a useful tool for teacher preparation programs seeking to shift their programs to meet the growing demands placed on secondary mathematics teachers.

Introduction

"Americans expect more than ever from schools," wrote Deborah Ball and Francesca Forzani, 10 years ago. This sentiment still applies today, as does their argument that "students' learning depends fundamentally on what happens *inside the classroom*" (Ball & Forzani, 2011, p. 17). Thus, the more educators learn about how students learn mathematics, the more expectations are thrust upon teaching. Teaching well includes cultivating mathematical proficiencies (National Research Council [NRC], 2001), mathematical practices (National Governors Association Center for Best Practices and the Council of Chief State School Officers [CCSSO], 2010), and essential concepts of mathematics (National Council of Teachers of Mathematics [NCTM], 2018). On top of a disciplinary agenda, teaching must also attend to the culture of a classroom environment and the cultural perspectives that students bring (National Academies of Science, Engineering, and Medicine, 2018). Demands on teachers have only increased, with respect to both their mathematical knowledge and their knowledge of and facility with core mathematics teaching. In this climate, teacher preparation programs must continually adapt to position teachers to succeed and thrive.

This need for adaptation is not new. A quarter-century ago, Smith (1996) identified challenges of centering teaching practice on student thinking when the competing practice of teaching through telling often reinforces teachers' belief that they will be successful as teachers. With respect to the preparation of prospective teachers, Smith argued that we might get at the “cracks” in the commitment to teaching through telling by providing prospective mathematics teachers (PSMTs) with opportunities to “link new mathematical experiences to their future practice” (p. 399). The MODULE(S^2) Project, which focuses on the mathematical education of prospective secondary teachers, centers its work on this notion. The project, and this report’s lead authors, contend that the connection between university content courses and teaching must be stronger, as well as that the connection to core mathematics teaching practices must be stronger. Specifically, the university mathematics courses that secondary mathematics teachers take are key spaces for PSMTs to develop their knowledge and confidence for implementing mathematically intensive teaching practices, applying the knowledge they have to secondary teaching situations across the diverse content discussed in *Catalyzing Change* (NCTM, 2018). Accordingly, the MODULE(S^2) Project has created materials that provide these opportunities in algebra, geometry, modeling, and statistics courses.

The authors have reported on MODULE(S^2) activities to develop PSMTs’ knowledge for teaching mathematics elsewhere (Lai et al., 2018; Lischka et al., 2020). In this paper, the researchers focus on the impacts of learning with MODULE(S^2) materials on secondary PSMTs’ expectancy and value for using core mathematics teaching practices (Grossman, Hammerness, & McDonald, 2009) that are mathematically intensive and center secondary students’ mathematical and statistical reasoning. Eccles and colleagues used expectancy to refer to one’s perceived expectation of probability of success on an upcoming task (1983). Value refers to the personal importance a person attributes to that task. Expectancy-value theory posits that performance, persistence, and choices are linked to individuals’ beliefs about expectancy and value related to particular tasks. The authors examine PSMT’s expectancy and value for enacting particular teaching practices as a predictor of their performance, persistence, and choices related to enacting core teaching practices. The MODULE(S^2) Project focuses on the following core practices:

- (CP1) regularly asking questions so that secondary students make conjectures,
- (CP2) regularly asking questions and leading discussions to help secondary students come up with justifications,
- (CP3) regularly asking questions that help secondary students understand how to build on their thinking and what to revise, and
- (CP4) regularly analyzing secondary students’ responses to understand their reasoning.

The project seeks to compare and contrast PSMTs’ expectancy and value for enacting core practices CP1-CP4 when teaching algebra, geometry, modeling, and statistics, and to understand the impact of PSMTs’ experiences with MODULE(S^2) materials on their expectancy and value for enacting these core practices across the different mathematical areas. The following research questions guided our study:

1. How do PSMTs’ value and expectancy for enacting CP1, CP2, CP3, and CP4 change, if at all before and after experiences with MODULE(S^2) materials?
2. How do shifts in PSMTs’ value and expectancy for enacting CP1-4 when teaching subjects that traditionally have been in the curriculum (algebra and geometry) compare to those for teaching subjects introduced more recently (modeling and statistics)?
3. Are there associations between PSMTs’ shifts in expectancy for enacting core practices and their perception of the degree to which their instructor enacted those core practices?

Broader Context and Background Literature

The U.S. educational system is in the midst of a major shift in mathematical standards and curricular recommendations. As institutions have worked to support teaching to the Common Core State Standards (CCSSO, 2010), professional organizations have offered detailed recommendations for effecting real change in how mathematics is taught (e.g., NCTM's *Catalyzing Change* in 2018; *MET II* from the Conference Board of the Mathematical Sciences in 2012), how statistics is taught (e.g., *GAISE II* (Bargagliotti et al., 2020) and *SET* (Franklin et al., 2015)), and how modeling is taught (e.g., Consortium for Mathematics and Its Applications & Society for Industrial and Applied Mathematics, 2019). Mathematicians and mathematics teacher educators alike recognize it is imperative that we utilize this deepening knowledge to improve the mathematical preparation of secondary teachers. The MODULE(S^2) Project focuses on what these advances mean for the mathematics content courses that PSMTs take.

Both pre- and in-service teachers have reported their perception that university content courses are ineffective with respect to instructional practices for high school teaching for two reasons: (1) the content seems irrelevant, and (2) the norms and skills for mathematical communication seem inapplicable (Deng, 2007; Moreira & David, 2008; Ticknor, 2012; Wasserman et al., 2015). Even if content courses address content, norms, and skills that are useful for teaching, teachers are unlikely to draw on resources they view as irrelevant. These factors point to the need for content courses to cultivate *mathematical knowledge in the context of instructional practices*. We propose that secondary teacher preparation programs should engage PSMTs in learning mathematical knowledge and then using that knowledge *for teaching*, in the context of simulations of core teaching practices. Following Grossman, Hammerness, and McDonald (2009) and Ball, Sleep, Boerst, and Ball (2009), we take core practices to be those that: (1) benefit the learning of the teachers' future students in equitable ways; (2) are learnable by prospective teachers; (3) depend on knowledge of mathematical structures and connections to carry out; and (4) when carried out skillfully, they equip teachers to improve their teaching. Further, the CPs are practices that secondary mathematics teachers have been documented to value, yet do not often carry out due to lack of confidence in their ability to enact them (Banilower et al., 2013).

Teachers' lack of confidence in teaching with CPs can be further complicated by the content they will teach in their future classrooms. For example, PSMTs have reported a significantly lower level of confidence in their ability to teach statistics when compared to more traditional topics such as algebra (Lovett, 2016). At the same time, university statistics courses provide a key place for providing opportunities for PSMTs to increase their confidence in and knowledge for teaching statistics (Azmy, 2020; Lovett, 2016). We find a similar account when it comes to teachers' sense of preparedness to teach modeling. The broad and deep mathematical approaches that students utilize when completing mathematical modeling tasks (Doerr, 2007) and the messy nature of the modeling process itself all serve to hamper PSMTs' confidence levels when it comes to teaching modeling (Zbiek, 2016).

This project seeks to gain an understanding of how the documented patterns in PSMT confidence in teaching secondary content might be disrupted by learning with MODULE(S^2) materials. Utilizing expectancy-value theory, the researchers posit that PSMTs' future teaching choices are linked to their perceived expectation of success (expectancy) at teaching tasks and the personal importance (value) they place on those tasks (i.e., core teaching practices [CPs]; Eccles, 1983; Eccles & Wigfield, 2002; Wigfield & Eccles, 2000). According to the theory, when both expectancy and value are high, the likelihood the teacher will make choices that lead to the desired performance of the task (teaching with CPs) is high. If either expectancy or value levels are low, then the other cannot compensate enough to lead to the desired outcome (Meyer et al., 2019; Trautwein et al., 2012). If MODULE(S^2) materials have an impact on raising expectancy and value for PSMTs' enactment of CPs in their future classrooms, then perhaps they can be a useful tool for colleges and universities seeking to improve their secondary teacher preparation programs.

Methodology

Context

MODULE(S^2) instructional materials are designed to promote the implementation of mathematically intensive core teaching practices (CPs) while PSMTs learn algebra, geometry, modeling, and/or statistics. This is accomplished as university instructors teach with the materials while implementing instruction that focuses on enabling PSMTs to explore conjectures and justifications as the instructor learns about PSMTs' understandings and uses their explanations, justifications, and representations during instruction. Additionally, the materials provide instructors with opportunities to have PSMTs apply their developing advanced mathematical understandings of secondary mathematics and statistics content to teaching situations. Structurally, each content area has a semester's worth of materials and is broken up into three modules.

The MODULE(S^2) team recruited faculty from across the U.S. to pilot a semester's worth of materials and collect PSMT data. The total time period for the data collection reported in this report is three years. Instructors piloting MODULE(S^2) materials met the following requirements: (1) the course where materials were used was mathematics content intensive and was a course that pre-service secondary teachers took, (2) two of the three modules within the content area were used during classroom instruction, (3) the piloting faculty participated in a four-day professional development experience prior to teaching with the materials, and (4) the piloting faculty participated in an ongoing instructor professional learning community throughout the academic year.

Participants

Students enrolled in college and university mathematics courses that used MODULE(S^2) materials to learn algebra, geometry, modeling, or statistics content at 22 different college or universities across the U.S. agreed to participate in this study. These participants fully completed the pre- and post-expectancy and value instruments, and 95% to 100% were PSMTs. Based on information gathered from the instructors, we know that 95% to 100% of the students in the algebra, geometry, and modeling were PSMTs (i.e., majoring in secondary education mathematics). Those students who did not major in secondary education mathematics were mathematics majors who took the course as an elective—many had interest in teaching at some point in their future experiences (e.g., as a GTA in a future master's program). For statistics courses, there was a smaller percentage (63%) of PSMTs. Therefore, we added a question to the statistics instrument so that we would only include PSMTs in the statistics data. Thus, although 70 statistics university students agreed to participate in the study, we only used data from the 44 who identified as PSMTs. The total number of participants in this study is 174, and we will refer to them as PSMTs. The participating institutions ranged from large public research universities to small private colleges and from Hispanic Serving Institutions and Historically Black Colleges and Universities to regional public universities.

Research Instruments

Research questions one and two address expectancy and value, and research question three focuses on expectancy. The research team measured PSMTs' expectancy and value for implementing the CPs of interest at the beginning and end of the term using items adapted from Banilower (2013) for expectancy items and from Markow and Pieters (2012) for value items. Specifically, expectancy items identified either three big ideas (algebra and geometry) or four big ideas (modeling and statistics) in each content area and asked PSMTs to rate on a Likert scale from 0 to 5 how confident they were that they could teach that big idea through implementing each of the CPs (0 being not at all and 5 being very much). For example, one of the algebra expectancy items for CP1 states (underlining is added here to indicate the big idea and bold is added to indicate the CP):

Suppose you are teaching middle or high school algebra students how to think about functions in terms of how changes in the value of one variable may impact the value of the other variable. How well does this statement describe how you feel? ***I would be comfortable regularly asking questions so that middle or high school students make conjectures***.

All of the expectancy items follow this structure—"Suppose you are teaching middle or high school [content area] students [about this big idea]. How well does this statement describe how you feel? I would be comfortable [engaging in CP1, 2, 3, or 4]."

The value items were not focused on specific content big ideas. Rather, they ask PSMTs to rate on a Likert scale from 1 to 5 how important it was to them to teach the content area in general using each of the CPs (1 being not at all and 5 being very much). For example, the algebra value item for CP1 states (bold is added to indicate the CP):

How much do you personally agree with these ideas about teaching algebra in middle or high school? ***I think it is important to regularly ask questions so that middle or high school students make conjectures****.*

All of the value items follow this structure—"How much do you personally agree with these ideas about teaching [content area] in middle or high school? I think it is important to [engage in CP1, 2, 3, or 4]."

Because the team measured expectancy for each core practice using either three or four big ideas in each content area, the analysis of the data must occur at the item response level rather than the participant level. The choice of number of big ideas on which to focus rested with the materials writing team for each content area based on the big ideas on which they desired data collection. Because the team averaged PSMTs' responses according to each CP, the number of big ideas on which data was collected for expectancy did not adversely affect the researchers' ability to compare across content areas. Table 1 reports how many PSMTs completed the expectancy and value instruments, how many colleges and universities these PSMTs were from, and how many PSMTs' item responses are included in the data set for each core practice. The number of PSMTs who completed all pre- and post-expectancy and value items was 174, and because there was one item response for each CP on the value instrument, there were 174 total item responses per CP for value. Because there were three or four item responses for each CP on the expectancy instrument, there were 592 total item responses per CP to analyze for expectancy.

Table 1

Number of Participants and Number of Expectancy-Value Item Responses for each Core Practice

Content Area	# of PSMTs	# of Colleges / Universities	Total # of Expectancy Item Responses for each CP	Total # of Value Item Responses for each CP
Algebra	54	5	162	54
Geometry	50	7	150	50
Modeling	26	4	104	26
Statistics (PSMTs)	44	6	176	44

To address research question three, the researchers measured PSMTs' perception of the extent to which they experienced a learning environment where the four CPs of interest were enacted. They adapted items from Markow and Pieters (2012) to measure student perceptions (SPs). Table 2 reports each SP item and the theorized associations between those SPs and the CPs of interest in this study. They hypothesized that if a PSMT perceives that a CP was implemented while they learned mathematics, then their expectancy for utilizing that CP in their future classroom will increase. If this is the case, a significant positive correlation between each SP item and the expectancy increase for the CP items theorized to be associated with it should occur. In the data collection, the SP instrument was administered following the expectancy and value instruments, and some PSMTs who completed the expectancy and value instruments did not click through to complete the SP instrument. Additionally, some PSMTs only partially completed the SP instrument. Therefore, the number of item responses was slightly smaller when calculating correlation data—varying from between 137 and 149 total item responses.

Table 2

Student Perception Items and Theorized Associations with Core Practices

Student (PSMT) Perception Item		Theorized CP Associations
How much do you personally agree with these descriptions of your class this term?		
SP1	My class participated in many discussions where we made conjectures.	CP1
SP2	My class participated in many discussions where we made mathematical justifications.	CP2
SP3	My instructor regularly asked us questions that helped us come up with conjectures.	CP1, CP3, CP4
SP4	My instructor regularly asked us questions that helped us make mathematical justifications.	CP2, CP3, CP4
SP6	My instructor regularly asked questions that helped us understand each other's ideas.	CP1, CP2, CP3, CP4
SP7	My instructor understands our explanations.	CP1, CP2
SP8	I came up with mathematical conjectures throughout the course.	CP1
SP9	I made mathematical justifications throughout the course.	CP2

Statistical Methods

This investigation utilized pre- and post-test measures of PSMTs' expectancy and value for implementing core mathematics teaching practices, along with a student perception inventory at the end of the term. Participants from multiple colleges and universities provided responses from multiple terms across two years of data collection. The research team cleaned the data using R to remove blank responses and responses of all 0, whose few instances were treated as input errors. Researchers began their analysis by creating stacked bar graphs of expectancy and value responses using Common Online Data Analysis Platform (CODAP) software. These displays show the movement from pre- to post-test for expectancy and value items at the categorical level. This allowed us to compare similarities and differences between the core mathematics teaching practices as well as between the four content areas. Next, the team computed descriptive statistics on the expectancy and value Likert scale data to compare pre-test means with post-test means across the four CPs for each content area. They conducted paired t-tests to determine statistically significant differences in means and computed Cohen's *d* effect size to determine the practical significance of mean differences for each CP within each content area. Finally, they computed correlation coefficients between each SP and the expectancy pre-post difference for the theorized associated CPs.

Results

In this section, the research team reports the results of a three-part analysis designed to investigate: (1) how PSMTs' value and expectancy for utilizing CPs compare across the four CPs and the four content areas, and (2) how PSMTs' perceived experiences of their instructors using CPs while they learned with MODULE(S^2) materials are correlated with the pre-post difference in their expectancy scores. Specifically, the results of categorical shifts from pre- to post-test on the expectancy and value instruments across CPs and content areas were reported. Second, the hypothesis was tested that the mean difference between pre- and post-tests for each CP on the expectancy and value instruments is equal to zero (H_0) versus that the claim that mean difference between pre- and post-tests for each CP on the expectancy and value instruments is different from zero (H_A). Finally, the researchers report the Pearson correlation coefficients calculated for the change in expectancy for CPs of interest and the theorized associations with each SP listed in Table 2. In these calculations, the researchers also report on the *p*-values for each correlation coefficient to test the hypothesis that there is no correlation between each SP and change in CP expectancy pair (H_0) versus the claim that there is a correlation between each SP and change in CP expectancy pair (H_A).

Figure 1 shows a display of stacked bar graphs of the value item responses at the beginning of the term administration of the instrument and the end of term administration. When looking across all content areas and core teaching practices, the value results are very similar. We see that the relative frequency of the combined five and four responses is between 80% and 90% for the beginning of term administration. At the end of term administration, the frequencies stayed in approximately the same range, with a noted difference that two of combined five and four responses reached above 95%. Although most of the levels are very similar, we do see that the modeling group showed the most movement in value from beginning to end, with CP1 and CP4 moving from 80% level to 95% for the combined four and five response.

A display of stacked bar graphs of the expectancy item responses at the beginning of the term and end of term administrations of the instrument is shown in Figure 2. Expectancy for all CPs showed meaningful migration toward the five, four and three categories at the end of term administration compared to the beginning. The proportional breakdown of five, four and three categories at the end of term administration look remarkably similar across all core practices and content areas alike. Patterns of note include that Modeling and Statistics showed a larger number of zero, one, and two expectancy responses in the beginning of term administration of the instrument. Additionally, the end of term administration showed a larger percentage of four and five responses for Algebra, Modeling, and Statistics when compared to Geometry. Specifically, the combined five and four responses for Geometry at around 70% compared to Algebra, Modeling, and Statistics, which has combined four and five response levels at between 80% and 90%. The beginning of term administration for Algebra shows a combined five and four response between 60% and 70%. Geometry and Statistics are similar to one another, with a combined five and four response right at 50%. Modeling has the lowest beginning of term administration combined five and four response at closer to 40%. With these patterns noted, we observe the largest migration of scores from pre to post in the Modeling data for the expectancy items.

Table 3 reports the descriptive and inferential statistics for the paired *t*-tests used to examine mean differences in value and expectancy items for each CP within each content area. All but one mean difference is positive across the entirety of the items. As the stacked bar graphs showed, there was not much room for increase in post-test scores, and the lack of statistically or practically significant improvement in value item scores (i.e., all but one of the Cohen's *d* effect sizes are below 0.4) reflects this. The expectancy items, however, tell a different story. Every increase in expectancy for each CP is statistically significant. Moreover, the effect sizes show that for modeling, the increase for every CP has high practical significance (i.e., effect sized are at 0.7 or more) and statistics increases show a moderate level of practical significance (i.e. all effect sizes are at 0.5 or 0.6). Effect sizes for algebra and geometry show only three of the eight differences with effect sizes between 0.4 and 0.5).

Figure 1. Responses for Value Items Across Content Areas and Core Mathematics Teaching Practices (CPs).

Figure 2. Responses for Expectancy Items Across Content Areas and Core Mathematics Teaching Practices (CPs).

Table 3

Results of Paired t-*tests for Value and Expectancy Items*

Algebra (Value)	*CP1*	*CP2*	*CP3*	*CP4*	*Total Mean*	*Algebra (Expectancy)*	*CP1*	*CP2*	*CP3*	*CP4*	*Total Mean*
Pre-Mean	4.296	4.278	4.444	4.519	4.384	Pre-Mean	3.722	3.698	3.938	4.000	3.840
Post-Mean	4.537	4.574	4.574	4.574	4.565	Post-Mean	4.296	4.284	4.265	4.327	4.293
Mean difference	0.241	0.296	0.130	0.056		Mean difference	0.574	0.586	0.327	0.327	
SD_d	0.751	0.882	0.912	0.738		SD_d	1.152	1.193	1.097	1.136	
n	54	54	54	54		*n*	162	162	162	162	
p-value	0.022	0.017	0.301	0.582		*p*-value	0.000	0.000	0.000	0.000	
effect size	0.321	0.336	0.142	0.075		effect size	0.498	0.491	0.298	0.288	

Geometry (Value)	*CP1*	*CP2*	*CP3*	*CP4*	*Total Mean*	*Geometry (Expectancy)*	*CP1*	*CP2*	*CP3*	*CP4*	*Total Mean*
Pre-Mean	4.280	4.500	4.480	4.560	4.455	Pre-Mean	3.593	3.520	3.527	3.693	3.583
Post-Mean	4.460	4.580	4.380	4.620	4.510	Post-Mean	3.967	4.047	4.000	4.147	4.040
Mean difference	0.180	0.080	-0.100	0.060		Mean difference	0.373	0.527	0.473	0.453	
SD_d	0.873	0.752	0.789	0.682		SD_d	1.277	1.180	1.268	1.229	
n	50	50	50	50		*n*	150	150	150	150	
p-value	0.151	0.455	0.374	0.537		*p*-value	0.001	0.000	0.000	0.000	
effect size	0.206	0.106	0.127	0.088		effect size	0.292	0.446	0.373	0.369	

Modeling (Value)	*CP1*	*CP2*	*CP3*	*CP4*	*Total Mean*	*Modeling (Expectancy)*	*CP1*	*CP2*	*CP3*	*CP4*	*Total Mean*
Pre-Mean	4.231	4.269	4.269	4.385	4.29	Pre-Mean	3.288	3.462	3.404	3.529	3.421
Post-Mean	4.500	4.615	4.500	4.577	4.55	Post-Mean	4.346	4.298	4.327	4.308	4.320
Mean difference	0.269	0.346	0.231	0.192		Mean difference	1.058	0.837	0.923	0.779	
SD_d	1.116	1.018	0.863	0.981		SD_d	1.261	1.239	1.196	1.106	
n	26	26	26	26		*n*	104	104	104	104	
p-value	0.230	0.095	0.185	0.327		*p*-value	0.000	0.000	0.000	0.000	
effect size	0.241	0.340	0.267	0.196		effect size	0.839	0.675	0.772	0.704	

Statistics (Value)	*CP1*	*CP2*	*CP3*	*CP4*	*Total Mean*	*Statistics (Expectancy)*	*CP1*	*CP2*	*CP3*	*CP4*	*Total Mean*
Pre-Mean	4.409	4.386	4.636	4.523	4.489	Pre-Mean	3.307	3.216	3.403	3.341	3.317
Post-Mean	4.705	4.705	4.705	4.705	4.705	Post-Mean	4.136	4.131	4.102	4.108	4.119
Mean difference	0.295	0.318	0.068	0.182		Mean difference	0.830	0.915	0.699	0.767	
SD_d	0.878	0.708	0.728	0.756		SD_d	1.448	1.492	1.392	1.522	

n	44	44	44	44	*n*	176	176	176	176
p-value	0.031	0.005	0.538	0.118	*p*-value	0.000	0.000	0.000	0.000
effect size	0.336	0.450	0.094	0.241	effect size	0.573	0.613	0.502	0.504

Producing a line graph of the pre and post means in total across all CPs for each content area provides another aggregate view of how increases from pre to post compare across content areas. In Figure 3, Modeling and Statistics follows a similarly sloped increase in value and expectancy. Geometry's increase in expectancy is similar to Algebra, but is flatter when it comes to value. The most dramatic improvement occurs for the Modeling data, which has the smallest pre-mean for value and the second smallest for expectancy. Modeling almost ties Algebra in the post-mean value score and has the highest expectancy post-mean value.

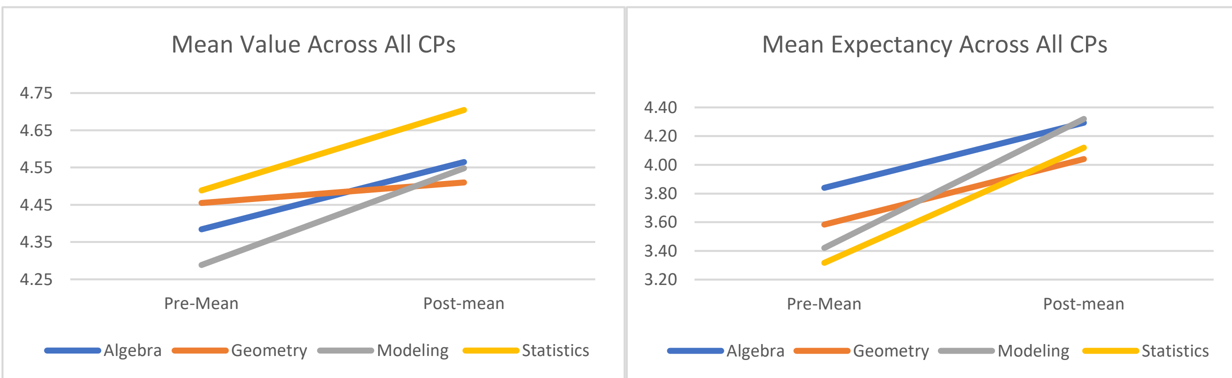

Figure 3. Pre- and Post-Means for Value and Expectancy Across All CPs for Each Content Area.

Pearson correlation coefficients were computed for each of the 16 theorized SP and CP expectancy difference pairs as listed in Table 2 for each of the four content areas. This results in a total of 64 correlation coefficients. Rather than reporting all of those coefficients, the results are summarized in Table 4. Because fewer students completed the student perception inventory, there are fewer numbers of SP items to match up with the expectancy items, and some students did not answer every item on the SP inventory. Thus, slight variations are seen in *n* for this analysis. With regard to results, it should be noted that although the correlation coefficients were small overall (i.e., only three *r* values reached the moderate level threshold of 0.3 for practical significance), the vast majority (53 out of 64) were positive and 14 had statistically significant *p*-values.

Table 4

Correlation Coefficient (r) Results for Student Perception and Core Practice Difference Data

Content Area	Minimum r	Maximum r	Number of r < 0	Number of r > 0	Number of SP item responses in data set	Number of r with p < 0.05
Algebra	-0.055	0.331	2	14	90	6
Geometry	-0.091	0.212	2	14	126-132	3
Modeling	-0.136	0.203	7	9	80	1
Statistics	0.002	0.218	0	16	48-144	4

In summary, results show a clear indication that the PSMTs learning with MODULE(S^2) materials increase in their expectancy for all four CPs in all four content areas. Even though pre-scores are high for both value and expectancy, the research team still observed statistically and practically significant increases in expectancy. Additionally, value levels were high in both the pre- and post-administrations of the expectancy-value instrument. This result is promising because high levels of both expectancy and value are predictors that the PSMTs will make choices in their future classrooms associated with persistence in the enactment of CPs (Meyer et al., 2019; Trautwein et al., 2012).

With regard to how PSMT's perception of use of CPs in their classroom experience correlated with an increase in their expectancy for utilizing CPs in their own future classrooms, an overwhelmingly positive number of correlations were observed. Although the practical significance of these correlations is not high, PSMTs' experience of the CPs that MODULE(S^2) prioritize may serve as a foundation for the opportunity for PSMTs to increase their expectancy for utilizing these CPs in their future classrooms.

Discussion

In this study, the researchers compared changes in prospective secondary teachers' expectancy and value for enacting core teaching practices across different content domains. They examined and found weak but overwhelmingly positive correlations between expectancy increases and PSMTs' perceived perceptions of learning in a course that utilized those core practices. More importantly, they found that there were increases, however modest, in both expectancy and value across the board. The most illuminating results pertained to the differences in gains across the content areas. In particular, there were larger practically significant increases in teachers' expectancies, for all core practices, in modeling and statistics than for algebra and geometry.

The problem that motivated this report is the increasing demand on teachers, including content demand. Not only are core teaching practices demanding with regard to application of content knowledge, but PSMTs across the U.S. are also likely to come into their teacher preparation programs with little if any modeling or statistical experience. In contrast, they likely enter their program with years of experience with algebra and geometry.

Based on the authors experiences working with prospective teachers and instructors of these courses, they hypothesize that one explanation for the differences they observed for gains in expectancy is that prospective teachers entering a modeling or statistics class have no prior reason to feel confident in that content, let alone teaching that content. However, prospective teachers will be more likely to have previously done well in their algebra and geometry classes, and perhaps even tutored or assisted other students in these topics. So, they may enter teacher preparation programs perceiving themselves as capable of teaching algebra and geometry—whether they understand what teaching mathematics entails.

In interpreting these results, alternative reasons for these gains must be considered. For instance, it may be that simply learning more content helped teachers feel more confident in enacting core practices. Alternatively, there may be a time effect, where teachers were going to increase in expectancy and value over time, regardless of the course taken or instruction provided. However, these potential alternative reasons for gains cannot completely explain the observed differences in changes in only expectancy across the domains.

In future work, the research team intends to expand its understanding of differences in expectancy and value gains across domains by providing an opportunity for PSMTs to retrospectively report their expectancy and value of core teaching practices coming into the course. The researchers observed in this study that administrations of the instruments resulted in rather large value and expectancy scores at the beginning of the term. This potentially hampered the instrument's ability to measure gains because it is common for people to not know what they don't know when coming into a new learning experience. To mitigate for this effect, it should be anticipated that a retrospective self-report at the end of term may provide data that more accurately captures PSTMs' expectancy and value gains over the term.

MODULE(S^2) materials are designed to provide opportunities for PSMTs to learn secondary mathematics and statistics from an advanced perspective while applying what they learn to secondary teaching situations. They have been shown to provide opportunities for PSMTs to build mathematical understandings that support the enactment of core teaching practices (Lischka et al., 2020), and in this investigation, an increase was documented in PSMTs' expectancy and value for enacting mathematically intensive core teaching practices designed to center student mathematical thinking in their future classrooms. As such, the authors contend that MODULE(S^2) materials can serve as a useful tool for teacher preparation programs across the country as they shift their programs to meet the growing demands placed on secondary mathematics teachers.

Author Note

Correspondence concerning this article should be addressed to Jeremy Strayer. This material is based upon work supported by the National Science Foundation under grant Nos. 1726707, 1726098, 1726252, 1726723, 1726744, and 1726804.

References

Azmy, C. (2020). *Secondary mathematics preservice teacher development of statistics teaching self-efficacy* (2020-31099-282; Issues 3-A). North Carolina State University.

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. In *Horizon Research, Inc.* Horizon Research, Inc. http://eric.ed.gov/?id=ED548238

Bargagliotti, A., Franklin, C., Arnold, P., Gould, R., Johnson, S., Perez, L., & Spangler, D. A. (2020). *Pre-K–12 guidelines for assessment and instruction in statistics education II (GAISE II): A framework for statistics and data science education* (Second edition). American Statistical Association.

Conference Board of the Mathematical Sciences (CBMS). (2012). *The mathematical education of teachers II* (Vol. 17). American Mathematical Society. https://www.cbmsweb.org/archive/MET2/met2.pdf

Consortium for Mathematics and Its Applications & Society for Industrial and Applied Mathematics. (2019). *GAIMME: Guidelines for assessment & instruction in mathematical modeling education* (2nd ed.). https://www.comap.com/Free/GAIMME/PDF/GAIMME_Report_2nd.pdf

Doerr, H. M. (2007). What knowledge do teachers need for teaching mathematics through applications and modelling? In W. Blum, P. L. Galbraith, H. Henn, & M. Niss (Eds.), *Modelling and applications in mathematics education* (Vol. 10, pp. 69–78). Springer. https://doi.org/10.1007/978-0-387-29822-1_5

Eccles, J. S. (1983). Expectancies, values, and academic beharиors. In J. T. Spence (Ed.), *Achievement and achievement motives: Psychological and sociological approaches* (pp. 75–146). W.H. Freeman and Company.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*, 109–132. https://doi.org/10.1146/annurev.psych.53.100901.135153

Franklin, C. A., Bargagliotti, A. E., Case, C. A., Kader, G. D., Scheaffer, R. L., & Spangler, D. A. (2015). *The statistical education of teachers*. American Statistical Association. https://www.amstat.org/education/SET/

Lai, Y., Strayer, J., & Lischka, A. E. (2018). Analyzing the development of MKT in content courses. In T. E. Hodges, G. J. Roy, & A. M. Tyminski (Eds.), *Proceedings of the 40th Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 496–499). University of South Carolina & Clemson University.

Lischka, A. E., Lai, Y., Strayer, J. F., & Anhalt, C. (2020). Developing mathematical knowledge in and for teaching in content courses. In G. W. Martin, B. R. Lawler, A. E. Lishka, & W. M. Smith (Eds.), *The Mathematics Teacher Education Partnership: The power of a networked improvement community to transform secondary mathematics teacher preparation* (pp. 119–141). Information Age Publishing.

Lovett, J. N. (2016). *The preparedness of preservice secondary mathematics teachers to teach statistics: A cross-institutional mixed method study* [North Carolina State University]. https://repository.lib.ncsu.edu/handle/1840.16/11008

Markow, D., & Pieters, A. (2012). The MetLife survey of the American teacher: Teachers, parents and the economy. In *MetLife, Inc.* MetLife, Inc. http://eric.ed.gov/?id=ED530021

Meyer, J., Fleckenstein, J., & Köller, O. (2019). Expectancy value interactions and academic achievement: Differential relationships with achievement measures. *Contemporary Educational Psychology*, *58*, 58–74. https://doi.org/10.1016/j.cedpsych.2019.01.006

National Academies of Science, Engineering, and Medicine. (2018). *Sexual harassment of women: Climate, culture, and consequences in academic sciences, engineering, and medicine* (P. A. Johnson, S. E. Widnall, & F. F. Benya, Eds.). National Academies Press.

National Council of Teachers of Mathematics (NCTM). (2018). *Catalyzing change in high school mathematics*. Author.

National Governors Association Center for Best Practices and the Council of Chief State School Officers (CCSSO). (2010). *Common core state standards*. Author. https://www.corestandards.org

National Research Council (NRC). (2001). *Adding it up: Helping children learn mathematics* (J. Kilpatrick, J. Swafford, & B. Findell, Eds.; Walker Library 372.7 Ad2k). National Academy Press.

Smith, J. P. (1996). Efficacy and teaching mathematics by telling: A challenge for reform. *Journal for Research in Mathematics Education*, *27*(4), 387–402. https://doi.org/10.2307/749874

Trautwein, U., Marsh, H. W., Nagengast, B., Lüdtke, O., Nagy, G., & Jonkmann, K. (2012). Probing for the multiplicative term in modern expectancy–value theory: A latent interaction modeling study. *Journal of Educational Psychology*, *104*(3), 763–777. https://doi.org/10.1037/a0027470

Wigfield, A., & Eccles, J. S. (2000). Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology*, *25*(1), 68–81. https://doi.org/10.1006/ceps.1999.1015

Zbiek, R. M. (2016). Supporting teachers' development as modelers and teachers of modelers. In C. R. Hirsch & A. R. McDuffie (Eds.), *Annual perspectives in mathematics education: Mathematical modeling and modeling mathematics* (pp. 263–272). NCTM.

Supporting Early-Career Secondary Mathematics Teachers to Impact Retention

Lisa Amick, University of Kentucky, lisaamick@uky.edu
Dawn Parker, Texas A&M University, dparker@tamu.edu
Laura Wilding, Texas A&M University, ljwilding@science.tamu.edu

Introduction

Approximately 12% of teachers in the United States leave the profession within their initial three years of teaching (Gray & Taie, 2015), the average national teacher turnover rate is approximately 8% a year (Sutcher et al., 2016), and the financial costs alone for replacing one teacher are estimated at $20,000 or more (Barnes et al., 2008). Half of all teachers are reported to leave the profession within their initial five years, and more alarming is that this rate is even higher for mathematics positions in high poverty schools (Fantilli & McDougall, 2009; Goldring et al., 2014). These staggering statistics too often lead to classrooms staffed with underprepared and/or unqualified teachers, which profoundly affects the mathematical preparation of students in high school, college, and beyond.

Experts agree that addressing the mathematics-teaching crisis meaningfully will require building a more cohesive system of educator preparation, support, and development (Mehta et al., 2015). Early-career teachers often feel isolated and those feelings of isolation are often associated with teachers leaving the field (Carroll & Fulton, 2004; Schlichte et al., 2005).

STRIDES (Supporting Teacher Retention and Induction in Diverse Educational Settings) is a national research team that is part of the Mathematics Teacher Education Partnership (MTE-Partnership) organized in cooperation with the Association of Public and Land-Grant Universities (APLU)'s Science and Mathematics Teacher Imperative. Since 2014 STRIDES has focused their research on teacher support and retention, because according to Sutcher et al. (2016), first-year turnover is cut by more than 50% when a focus is put on early career teacher mentoring, collaboration, and inclusion in a strong teacher network. The work of STRIDES is centered on this "cohesive system" that supports teachers from their educator preparation program throughout the early years in their careers. STRIDES believes that the support system must include numerous constituents such as university partners, mentor and veteran teachers, cooperating teachers, and administrators, as well as early career teachers themselves.

Effective Teacher Support

Effective teacher support is necessary as early-career teachers navigate the challenges that may impact their decision to stay in the profession. A comprehensive induction program includes opportunities to: 1) work with other colleagues in learning communities, 2) observe experienced teachers' classrooms, 3) be observed by expert mentors, 4) analyze one's practice, and 5) network with other early-career teachers. Unfortunately, less than 1% of teachers receive all of these components in their induction programs (Ingersoll & Smith, 2016); however, one support that has been reported and perceived as beneficial is developing a relationship with a mentor teacher whom they can trust (Martin et al., 2015). It is helpful to have a person on campus to rely on for basic questions, someone to assist with the necessary paperwork and to be "a shoulder to cry on" in a time of need. In addition to this "buddy role," the mentor teacher needs to have the training and skills to impact teaching practices and student learning (Feiman-Nemser, 2012).

When early-career and mentor teachers collaborate to improve instruction, students learn more and teachers have higher job satisfaction (Johnson et al., 2005; DuFour, 2015). Even though many reasons influence teacher retention, from pay and teaching assignments to support from administrators and opportunities for professional growth, research has shown that a teacher's sense of being effective impacts their job satisfaction, which in turn, impacts retention (Johnson and Birkeland, 2016).

The Past Work of STRIDES

To respond to the teacher retention crisis, STRIDES created a survey as an initial step to study the current support systems of early-career secondary mathematics teachers. One research question guiding this work was: What is the perceived scope, nature, and impact of professional support for early career mathematics teachers? This survey was created through an iterative design and vetting process (protype, test, tweak, repeat) that extended from the fall of 2014 to early 2016. The main goal of the survey was to better understand the degree to which early- career mathematics teachers perceived various learning opportunities as influential to their interest in teaching mathematics. By better understanding current support systems, the team could develop interventions that would strengthen and replicate systems that were working and attempt to improve broken ones. The survey consisted of 25 questions asking respondents to report on their current support systems, job satisfaction, projected longevity in the field, and other related topics. The survey was given in November of 2016 and gleaned 141 responses from teachers across the nation. Results from this study are presented in Amick et al. (2020).

The vast majority of early-career teachers surveyed had received mentoring or coaching from someone at their school site, and almost (89%) all of them found that experience to be moderately or very influential to their enthusiasm for teaching mathematics. This finding is consistent with other research on induction programs (Ingersoll & Strong, 2011; Youngs et al., 2019). In their review, Ingersoll and Strong (2011) found that induction programs and especially teacher mentoring programs positively influenced early-career teachers' satisfaction, commitment, and/or retention. This result suggests that local support from a mentor or coach is a vital component to new teacher success that needs to be replicated for new teachers lacking such support. Another survey finding was that approximately 10% of teachers wanted more meaningful support from their administration. Teachers reported going to administrators for a variety of needs (curriculum, classroom management, course assignments, assessment, instruction, collaboration and affirmation), but that desired support was often lacking or was "not valuable". STRIDES identified this as a focal area because teachers who feel that they are supported by their administrators are more likely to be satisfied with their career and remain in teaching longer than those who do not feel supported (Djonko-Moore, 2016; Redding & Henry, 2018; Ronfeldt & McQueen, 2017).

Based on the survey findings and supported by past research, two interventions were designed and piloted during the 2018–2019 and 2019–2020 academic years. The interventions were designed to provide targeted support to first-year teachers by: (1) strengthening the mentor/mentee relationship with the school principal through monthly communications over suggested discussion topics, and creating these relationships where they did not currently exist; (2) strengthening the relationship between these teachers and their administrators via 5-minute video discussions on best practice strategies for teaching mathematics. The overall methodology for this work was a design experiment approach (Cobb et al., 2016), focusing on a problem in practice and pragmatically designing an intervention to impact that problem with multiple iterations of implementation and (re)design. In keeping with a design experiment approach, the interventions were modified over the two years, based on continuous analyses, in an effort to improve the interventions. The main data sources collected were end-of-the-year surveys from the participating teachers, mentors, and administrators, and informal communications such as emails and personal conversations.

Over the two years that the pilot interventions were tested, one major finding arose: the idea that university support is most effective and useful during the pre-service years, but once teachers begin their first year teaching, university support gives way to local support and teacher self-efficacy. This is consistent with other research in the field such as Scherer (2012) and Hunt (2014) that both show university support to dwindle as the teacher progresses throughout his/her career. As much as STRIDES tried to dovetail the interventions into existing mentoring systems, the intervention tasks still felt like “one more thing” to the teachers and often were not a priority. This led STRIDES to realize that early-career teacher support occurs over a continuum, starting with the pre-service years, transitioning into the early years of their careers, and that the support each year looks different, with the major constituents changing over time. STRIDES research, supported by past research, shows that extensive, cohesive, and organized support systems are one of the most influential aspects impacting teacher retention (Ingersoll & Strong, 2011; Youngs et al., 2019; Sutcher et al., 2016). For these systems to operate optimally and have the greatest impact on teacher retention, STRIDES advocates that the support must begin during the pre-service years of a teacher’s career, extend through the first critical years, and involve numerous constituents with well-defined roles. Figure 1 shows the early years of a teacher’s career and how university partners provide substantial support early on, and are replaced by teachers’ colleagues/mentors and administration, with the teacher eventually relying heavily on self-efficacy for the main means of support.

Figure 1. Cohesive Support System.

Support System Responsibilities

Guarino et al. (2006) show that the more types of support teachers experience, the lower the likelihood of their leaving or changing schools. Support can and should include supportive administration, collegiality within their schools, professional development opportunities, community support, support from university partners, and even self-efficacy and self-advocacy. Those with roles in providing this support include: university partners, mentors/veteran teachers, administration, and the beginning teacher.

University Partners

One way that the community can support early-career teachers is to have strong connections with university partners. School-university partnerships have potential for connecting theory to practice in meaningful ways in the first years of teaching (Hunt, 2014). University partners can champion and advocate for policies in the profession that better serve teachers and students. However, partnerships too often focus only on clinical experiences with pre-service teachers and mentors and therefore have limited impact during the induction years (Scherer, 2012). Nonetheless Bastian & Marks (2017) found increased retention rates for first year teachers utilizing a university-school induction program. Programs designed to support early-career teachers provide benefits to both universities and schools, leading not just to better outcomes for students, but also for educators at all levels to learn from each other (Ball & Cohen, 1999).

Early-Career Teacher's Colleagues

The early-career teacher's colleagues have a lot of responsibility to help support and retain their newly hired colleague (Daly, 2010; Le Cornu, 2013). High quality collegial relationships on an emotional and social level support beginning teachers and help them feel part of the team (Thomas et. al, 2019). Being available for lesson planning assistance and feedback after an observation, while important, is often not enough. Early-career teachers report looking for their coworkers to show kindness, patience, and a willingness to collaborate and change practice based on what is best for students (Shoval et al., 2010). Early-career teachers often report feeling most supported by personal relationships with approachable colleagues (Resta et al., 2013). In fact, feedback is better received when it is based on a trusting relationship. For a couple of reasons the responsibility for developing these relationships falls on the early-career teacher's colleagues. First, the early-career teacher is often too overwhelmed to make time to initiate these relationships, and, second, the early-career teacher often feels like an outsider as a new member to the school community.

Administrators

As evidenced by the graph above, administrators play a crucial support role, especially in the first year. Teachers who feel that they are supported by their administrators in carrying out professional responsibilities are more likely to be satisfied with their career and remain in teaching longer than those who do not feel this support (Djonko-Moore, 2016; Podolsky et al., 2016; Redding & Henry, 2018; Ronfeldt & McQueen, 2017). Teachers' responses to administrative practices can affect teacher trust of administration, the ability of teachers to ask for support, and their general ability to do their job effectively (Corbell, Osborne & Reiman, 2010; Hanselman, 2016; Ladd, 2011). A number of studies focus on the ability of school administrators to ensure that the school environment is supportive of teaching, with effective professional development, substantive evaluations of teaching, and avenues for engagement with other teachers and members of the local community (Carver-Thomas & Darling-Hammond, 2017; Dizon-Ross, 2018; Ford, Urick & Wilson, 2018).

Early-Career Teachers

Early-career teachers themselves also have a responsibility for their role in this cohesive support system. They need to be willing to ask for help when they are struggling or feeling overwhelmed (Darvin, 2018). They should be aware that teacher burnout exists and take action to prevent it (Little & Bartlett, 2002), including not grading every paper that comes across their desk, making time for self-care, and working to create a manageable work-life balance. New teachers operate on a big learning curve, so embracing mistakes or hard situations as learning opportunities rather than internalizing them is another key to avoiding burnout (Sackstien, 2018).

Teaching Year	Constituent	Level of Support	Types of Support
Preservice Year	University Partners	strong	model and promote research based teaching practices, provide seminars for teacher candidates on job securing process, coordinate field placements for teacher candidates, build relationships with classroom teachers and administrators
	Early Career Teacher's Colleagues	strong	serve as cooperating teachers, providing continual constructive criticism on content and pedagogy, help with job searches and interview preparations
	Administration	minimal	encourage preservice teachers in the building and provide constructive criticusm on teaching
	Pre-service Teacher	moderate	focus on learning outcomes, create a professional network and begin to use it
Year 1	University Partners	moderate	be available for content and pedagogy questions and resources, encourage community within newly graduated teacher cohorts, keep current on research that shows positive effects on teacher retention, work with mentors and administration to hep with on-site support, discuss with principals how to specifically support new teachers
	Early Career Teacher's Colleagues	strong	serve as mentors, advocate for less classes or an extra prep period
	Administration	strong	and consider lighter teaching loads, less extra curriculars, and/or extra prep periods, develop personal and professional relationsips of mutual respect with new teacher, purposfully assign a mentor and create time and space for that relationship to develop, conduct early on, low-stakes observations with meaningful feedback, recognize and support the teacher as the subject matter and pedagogical expert
	Novice Teacher	moderate	ask for help and be open to constructive criticism, priortize tasks, set limits and focus on effective processes, put time and effort into professional growth, use your professional network (mentor, cooperating teacher, university professors, etc.)
Year 2	University Partners	minimal	provide professional development as needed
	Early Career Teacher's Colleagues	moderate	serve as mentors, advocate for less classes or an extra prep period
	Administration	moderate	provide meaningful feedback via observations that are content and pedagogy specific
	Early Career Teacher	moderate	Seek out professional development opportunities, use your professional network
In General	University Partners		champion educational friendly policies, advocate for the professionalization of teaching, stay abreast of current research and use it to update programs to meet the changing needs of educator preparation programs
	Early Career Teacher's Colleagues		be approachable and make early career teachers feel welcomed and part o the team, assist with lesson planning, analyzing student work, assessment data, and assist with classroom management
	Administration		champion equitable working conditions for teachers (class size, supplies, planning time, etc.), provide technical infrastructure as needed, offer meaningful and effective professional development, be trustworthy and approachable, foster a school climate that is supportive of growth mindet and mistake making, advocate for community support, acknowledge teacher accomplishments and successes, effectively evaluate teaching in a collaborative manner
	Pre-service Teacher		maintain healthy work/life balance, use reflective practices such as journaling and professional noticing to improve teaching, continually update and utilize professional networks, seek out professional growth experiences

Figure 2. Types of Support Over Time.

In her book *Risk.Fail.Rise.: A Teacher's Guide to Learning from Mistakes,* Maria Colleen Cruz (2020) argues that mistakes are not the problem. Rather the problem is the shame attached to mistakes and the inability to grow from them. Early-career teachers tend to be hard on themselves, so it is crucial they have a mindset that destigmatizes mistake-making. This will allow new teachers to do the real work of professional growth, as well as to model through their own mistake-making and improve their responses to others' mistakes. Being a lifelong learner is important, and early-career teachers must be willing and eager to receive and act upon constructive criticism to improve their practice (Martin et al., 2015).

Putting effort into professional relationships and seeking professional development should also be a focus, as those professional networks have shown to impact retention (Johnson et al., 2005). Not only is each constituent's role important in the early-career teacher support process, but those roles change over time. For example, university support is strong during the pre-service years but gives way as the early career teacher develops self-efficacy and local connections. Figure 2 begins to outline what this support looks like in the pre-service year, the first two years of teaching, and also lists some general support strategies that the supporting constituents can use. This figure was created by the STRIDES team as a way to merge past research into the work they have done over the past several years. This tool can be used by districts to provide a meaningful and cohesive support system for their early-career teachers.

Conclusion

While much focus is on why teachers leave the profession, there are teachers who persist. Identifying the factors that impact stayers and leavers is important in creating the support systems for early-career teachers (Inman & Marlow, 2004; Hong, 2012). Veteran teachers value interactions and support of colleagues, and what keeps them coming back is a desire to master their craft and have an impact with meaningful work (Barnes, 2019). Teachers who stay and thrive do so because of a combination of supports that are strong, reliable, and consistent with professional goals and expectations. With strong support systems, the hope is to have more teachers persist and have an impact on the teacher attrition issue.

Author Note

We have no known conflict of interest to disclose. Correspondence concerning this article should be addressed to Lisa Amick, College of Education, Department of STEM Education, University of Kentucky, 105 Taylor Education Building, Lexington, KY 40506-0017.

Definitions

- Pre-service Teacher - *a student enrolled in an education preparation program prior to certification/licensure*
- Cooperating Teacher - *certified teacher mentoring a pre-service teacher in the area of certification*
- Early-Career Teachers - *teachers in their initial three years of teaching*

References

Ball, D. L., & Cohen, D. K. (1999). In Darling-Hammond L., Sykes G.(Eds.), *Teaching as the learning profession*. Jossey-Bass.

Barnes, G., Crowe, E., Schaefer, B., & National Commission on Teaching & America's Future (U.S.). (2008). *The cost of teacher turnover in five school districts [electronic resource]: A pilot study / Gary Barnes, Edward Crowe, Benjamin Shaefer.*

Barnes, P. (2019). *Why I stay in teaching.* Edutopia. https://www.edutopia.org/article/why-i-stay-teaching

Bastian, K. C., & Marks, J. T. (2017). Connecting teacher preparation to teacher induction: Outcomes for beginning teachers in a university-based support program in low-performing schools. *American Educational Research Journal, 54*(2), 360–392. https://10.3102/0002831217690517

Carroll, T., & Fulton, K. (2004). The true cost of teacher turnover. *Threshold, 8*(14), 16–17.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2016). Design experiments in educational research. *Educational Researcher, 32*(1), 9–13. https://10.3102/0013189x032001009

Cruz, M. C. (2020). *Risk. Fail. Rise.: a teacher's guide to learning from mistakes*. Heinemann.

Daly, A. J. (2010). *Social network theory and educational change*. Harvard Education Press.

Darvin, J. (2018). Widening the mentoring circle. *Educational Leadership, 75*(9), 52–57.

DuFour, R. (2015). Professional Learning Communities: A bandwagon, an idea worth considering, or our best hope for high levels of learning? *Middle School Journal, 39*(1), 4–8. https://10.1080/00940771.2007.11461607

Fantilli, R. D., & McDougall, D. E. (2009). A study of novice teachers: Challenges and supports in the first years. *Teaching and Teacher Education, 25*(6), 814–825. https://10.1016/j.tate.2009.02.021

Feiman-Nemser, S. (2012). *Beyond SOLO Teaching*. Association for Supervision and Curriculum Development.

Goldring, R., Taie, S. & Riddles, M. (2014). *Teacher Attrition and Mobility: Results from the 2012/13 Teacher Follow-Up Survey: 2012/13 Schools and Staffing Survey;2014 ASI 4826-41.2; NCES 2014-077.* Washington, D.C.: National Center for Education Statistics: U.S. Department of Education. https://statistical.proquest.com/statisticalinsight/result/pqpresultpage.previewtitle?docType=PQSI&titleUri=/content/2014/4826-41.2.xml

Gray, L., & Taie, S. (2015). *Public school teacher attrition and mobility in the first five years*. U.S. Department of Education, National Center for Education Statistics, Institute of Education Sciences.

Guarino, C. M., Santibañez, L., & Daley, G. A. (2016). Teacher recruitment and retention: A review of the recent empirical literature. *Review of Educational Research, 76*(2), 173–208. https://10.3102/00346543076002173

Hong, J. Y. (2012). Why do some beginning teachers leave the school, and others stay? Understanding teacher resilience through psychological lenses. *Teachers and Teaching, Theory and Practice, 18*(4), 417–440. https://10.1080/13540602.2012.696044

Hunt, C. S. (2014). A review of school-university partnerships for successful new teacher induction. *School-University Partnerships, 7*(1), 35–48.

Ingersoll, R. M., & Strong, M. (2011). The impact of induction and mentoring programs for beginning teachers: A critical review of the research. *Review of Educational Research, 81*(2), 201–233. https://10.3102/0034654311403323

Ingersoll, R. M., & Smith, T. M. (2016). Do teacher induction and mentoring matter? *NASSP Bulletin, 88*(638), 28–40. https://10.1177/019263650408863803

Inman, D., & Marlow, L. (2004). Teacher retention: Why do beginning teachers remain in the profession? *Education (Chula Vista), 124*(4), 605–614.

Johnson, S., Berg, J., & Donaldson, M. (2005). *Who stays in teaching and why: A review of the literature on teacher retention (a project on the next generation of teachers)*. Harvard Graduate School of Education.

Johnson, S. M., & Birkeland, S. E. (2016). Pursuing a "sense of success": New teachers explain their career decisions. *American Educational Research Journal, 40*(3), 581–617. https://10.3102/00028312040003581

Le Cornu, R. (2013). Building early career teacher resilience: The role of relationships. *The Australian Journal of Teacher Education, 38*(4), 1–16. https://10.14221/ajte.2013v38n4.4

Little, J. W., & Bartlett, L. (2002). Career and commitment in the context of comprehensive school reform. *Teachers and Teaching, Theory and Practice, 8*(3), 345–354. https://10.1080/135406002100000486

Martin, K. L., Buelow, S. M., & Hoffman, J. T. (2015). New teacher induction: Support that impacts beginning middle-level educators. *Middle School Journal, 47*(1), 4–12. https://10.1080/00940771.2016.1059725

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

Resta, V., Huling, L., & Yeargain, P. (2013). Teacher insights about teaching, mentoring, and schools as workplaces. *Curriculum and Teaching Dialogue, 15*(1-2), 117–132. https://search.proquest.com/docview/1449497243

Scherer, M. (2012). The challenges of supporting new teachers: A conversation with Linda Darling-Hammond. *Educational Leadership, 69*(8), 18–23.

Schlichte, J., Yssel, N., & Merbler, J. (2005). Pathways to burnout: Case studies in teacher isolation and alienation. *Preventing School Failure, 50*(1), 35–40. https://10.3200/psfl.50.1.35-40

Shoval, E., Erlich, I., & Fejgin, N. (2010). Mapping and interpreting novice physical education teachers' self-perceptions of strengths and difficulties. *Physical Education and Sport Pedagogy, 15*(1), 85–101. https://10.1080/17408980902731350

Sutcher, L., Darling-Hammond, L., & Carver-Thomas, D. (2016). *A Coming Crisis in Teaching? Teacher Supply, Demand, and Shortages in the U.S*. National Science Teachers Association.

Thomas, L., Tuytens, M., Moolenaar, N., Devos, G., Kelchtermans, G., & Vanderlinde, R. (2019). Teachers' first year in the profession: The power of high-quality support. *Teachers and Teaching, Theory and Practice, 25*(2), 160–188. https://10.1080/13540602.2018.1562440

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 978-1-7923-9077-7