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

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

Overview and Problem Statement

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

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

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

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

Current Progress of the Work

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

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

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

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

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

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

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

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

Table 1

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

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

Accomplishments at the MTE-Partnership 2018 Meeting

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

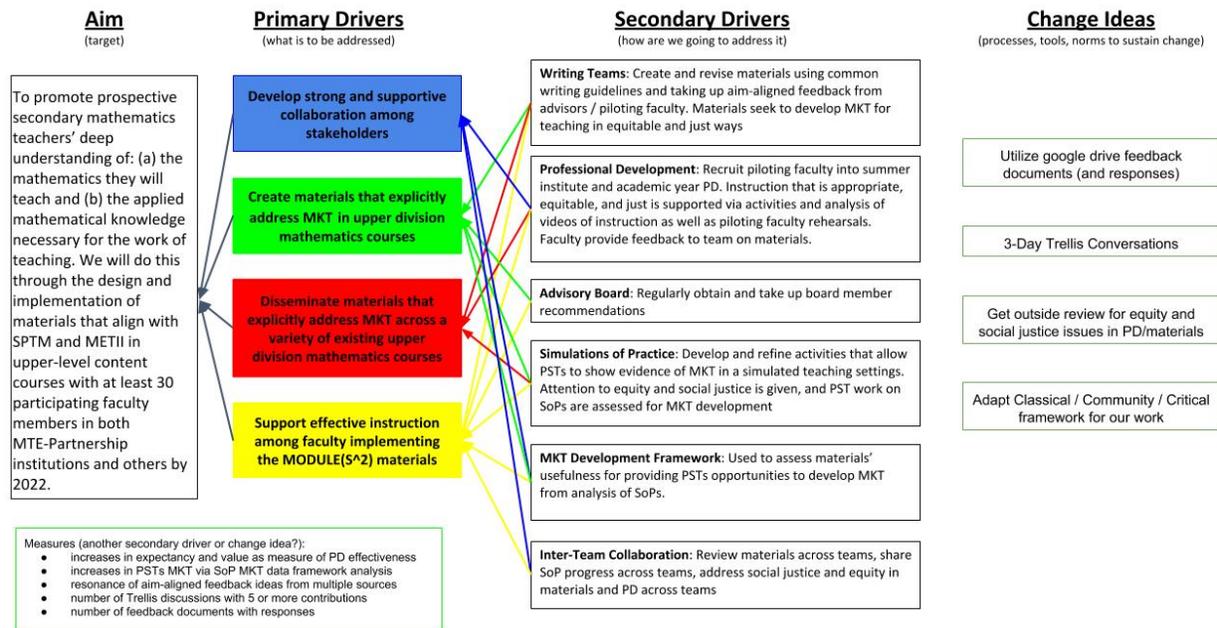


Figure 1. Draft MODULE(S²) revised driver diagram.

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

Moving Forward and Opportunities for Engagement

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

engaging with the materials develop knowledge needed for teaching.

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

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

References

- Ader, S. B., & Carlson, M. P. (2018, February). *Observable manifestations of a teacher's actions to understand and act on student thinking*. Paper presented at the annual meeting of the Special Interest Group of the Mathematical Association of America on Research in Undergraduate Mathematics Education, San Diego, CA.
- Association of Mathematics Teacher Educators. (2017). *Standards for preparing teachers of mathematics*. Retrieved from: <http://www.amte.net/standards>
- Banilower, E. R., Smith, P. S., Weiss, I. R., Malzahn, K. A., Campbell, K. M., & Weis, A. M. (2013). *Report of the 2012 National Survey of Science and Mathematics Education*. Chapel Hill, NC: Horizon Research, Inc.
- Conference Board of the Mathematical Sciences. (2012). *The Mathematical education of teachers II*. Providence, RI, and Washington, DC: American Mathematical Society and Mathematical Association of America. Retrieved from <http://www.cbmsweb.org/MET2/MET2Draft.pdf>
- Goulding, M., Hatch, G., & Rodd, M. (2003). Undergraduate mathematics experience: Its significance in secondary mathematics teacher preparation. *Journal of Mathematics Teacher Education*, 6(4), 361–393.
- Rowland, T., Thwaites, A., & Jared, L. (2016, July). *Analysing secondary mathematics teaching with the Knowledge Quartet*. Paper presented at the 13th International Congress on Mathematical Education, Hamburg, Germany.
- Silverman, J., & Thompson, P. W. (2008). Toward a framework for the development of mathematical knowledge for teaching. *Journal of Mathematics Teacher Education*, 11(6), 499–511.
- Stylianides, G.J., & Stylianides, A.J. (2010). Mathematics for teaching: A form of applied mathematics. *Teaching and Teacher Education*, 26(2) 161–172.
- Zazkis, R., & Leikin, R. (2010). Advanced mathematical knowledge in teaching practice: Perceptions of secondary mathematics teachers. *Mathematical Thinking and Learning*, 12, 263–281.