
MODULE(S²) RAC Report: Blending Content and Mathematical Knowledge for Teaching in Mathematics Courses

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

Emina Alibegovic, Rowland Hall-St. Mark's School, eminaalibegovic@rowlandhall.org

Overview and Problem Statement

The Mathematics of Doing, Understanding, Learning, and Educating for Secondary Schools [MODULE(S²)] Research Action Cluster (RAC) is focused on the development of prospective secondary mathematics teachers' (PSMTs') knowledge of mathematics content needed to support student learning. This focus addresses recommendations set forth in *The Mathematical Education of Teachers II* (MET II) (Conference Board of the Mathematical Sciences [CBMS], 2012) for courses in secondary mathematics teacher preparation programs to provide opportunities for prospective teachers to “delve into the mathematics . . . while engaging in mathematical practice as described by the CCSS” (p. 46). The work of the RAC aims to address the identified problem that undergraduate programs fail to lead teacher candidates to: a) deeply understand the mathematics they will actually teach and b) experience learning in a manner consistent with what will be expected of them as professional educators (Banilower et al., 2013).

In response to this problem, the MODULE(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.

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

Current State of the Work

In the 2015-2017 academic years, the MODULE(S²) RAC continued work on multiple fronts: writing and revising modules in Geometry and Statistics, piloting existing modules in a variety of locations, planning for modules in Algebra and Modeling, presenting results of pilot studies, and submitting a successful proposal for an NSF-IUSE grant to fund the work of the MODULE(S²) RAC.

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

The Geometry group, led by Emina Alibegovic and Alyson Lischka, collaborated with piloters in spring 2017 at California State University Monterey Bay, Auburn University, University of North Dakota, and Grand Valley State University. In February 2017, at the Association of Mathematics Teacher Educators annual conference, Lischka and Jeremy Strayer (along with two doctoral students from Middle Tennessee State University) presented results from a pilot study conducted on the Geometry Modules in Spring 2016 (Lischka, Strayer, Alibegovic, Watson, & Quinn, 2017). The group shared elements of the modules and pre- and post-assessments of student work that resulted from the course. Results indicated that students engaging with these modules increased their mathematical knowledge for teaching geometry according to the Silverman and Thompson (2008) framework. The session was well attended and the audience thoughtfully engaged with the discussions, helping MODULE(S²) spread the word of our work. Revisions of the Geometry Modules continue based on feedback from piloters and the results of the pilot study.

In January 2017, the MODULE(S²) RAC submitted an NSF-IUSE proposal for a five-year project to develop, pilot, and revise modules for use in College Geometry, Statistics, Mathematical Modeling, and Abstract Algebra. The collaborative proposal, *Collaborative Research: Mathematics of Doing, Understanding, Learning and Educating for Secondary Schools* (NSF Awards #1726707, 1726098, 1726252, 1726723, 1726744, and 1726804), was awarded full funding beginning September 1, 2017. The goals of the project are:

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

The MODULE(S²) grant team is led by Strayer (Middle Tennessee State University) and Howard Gobstein (Association of Public and Land-Grant Universities). Collaborators include: Alibegovic (Rowland Hall School), Cynthia Anhalt (University of Arizona), Jason Aubrey (University of Arizona), Casey (Eastern Michigan University), Brynja Kohler (Utah State University), Yvonne Lai (University of Nebraska – Lincoln), Lischka (Middle Tennessee State University), and Ross (Eastern Michigan University).

The MODULE(S²) RAC used work time at the Mathematics Teacher Education Partnership June meeting to organize the logistics of the work of the grant and set specific goals and timelines for making significant progress on the writing of the modules within the first year of the grant.

Moving Forward

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

For More Information

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

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