Active Learning in Mathematics Research Action Cluster (ALM RAC)

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Problem Addressed

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

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

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

General Approach

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

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

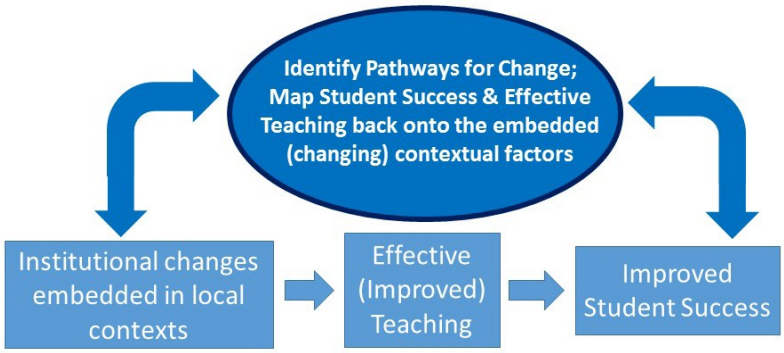

Figure 1. ALM RAC theory of change.

Table 1
Who We Are

Auburn
Ulrich Albrecht, Gary Martin

California Polytechnic Institute Pomona
Laurie Riggs

California State University Fullerton
Alison Marzocchi, David Pagni, Roberto Soto

Colorado State University
Janet Oien

California State University Chico
Christine Herrera

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

Fresno State
Lance Burger

Kennesaw State University
Kadian Callahan, Belinda Edwards

Middle Tennessee State University
James Hart

San Diego State University
Janet Bowers, Michael O'Sullivan, Chris Rasmussen, Daniel Reinholz, Matt Voigt

Tuskegee University
Lauretta Garrett, Ana Tameru

University of Colorado Boulder
David Webb*, Robert Tubbs, David Grant
Faan Tone Liu, Eric Stade, Nancy Kress

University of Hawaii Manoa
Monique Chyba, Mijana Jovovic, Sarah Post

University of Nebraska-Lincoln
Wendy Smith*, Allan Donsig, Nathan Wakefield

University of Nebraska at Omaha
Janice Rech, Michael Matthews

University of Northern Arizona
Angie Hodge

University of South Carolina
Sean Yee

Utah State University
KimberLeigh Hadfield

West Virginia University
Vicki Seeley, Nicole Engelke, Matthew Campbell

Western Michigan University
Tabitha Mingus, Melinda Koelling

*RAC co-leaders

Current Progress

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

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

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

Opportunities for Engagement

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

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

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

Work of the 2018 Conference

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

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

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

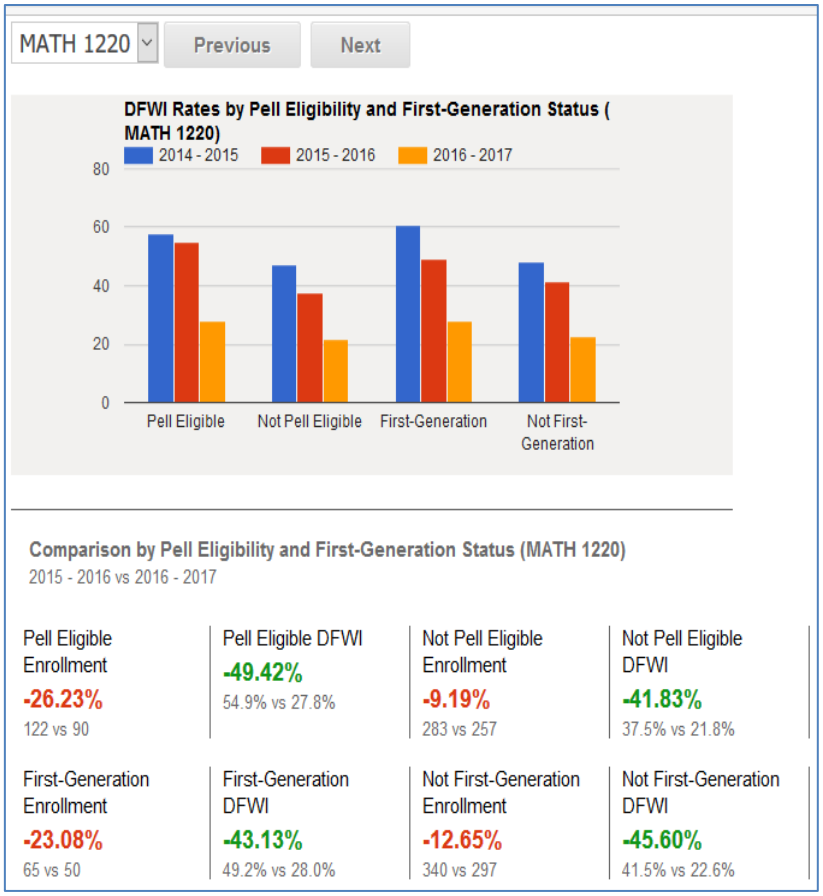

Figure 2. Western Michigan University's student success rates in Calculus 1 since 2014, disaggregated by Pell eligibility and first-generation college student status.

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

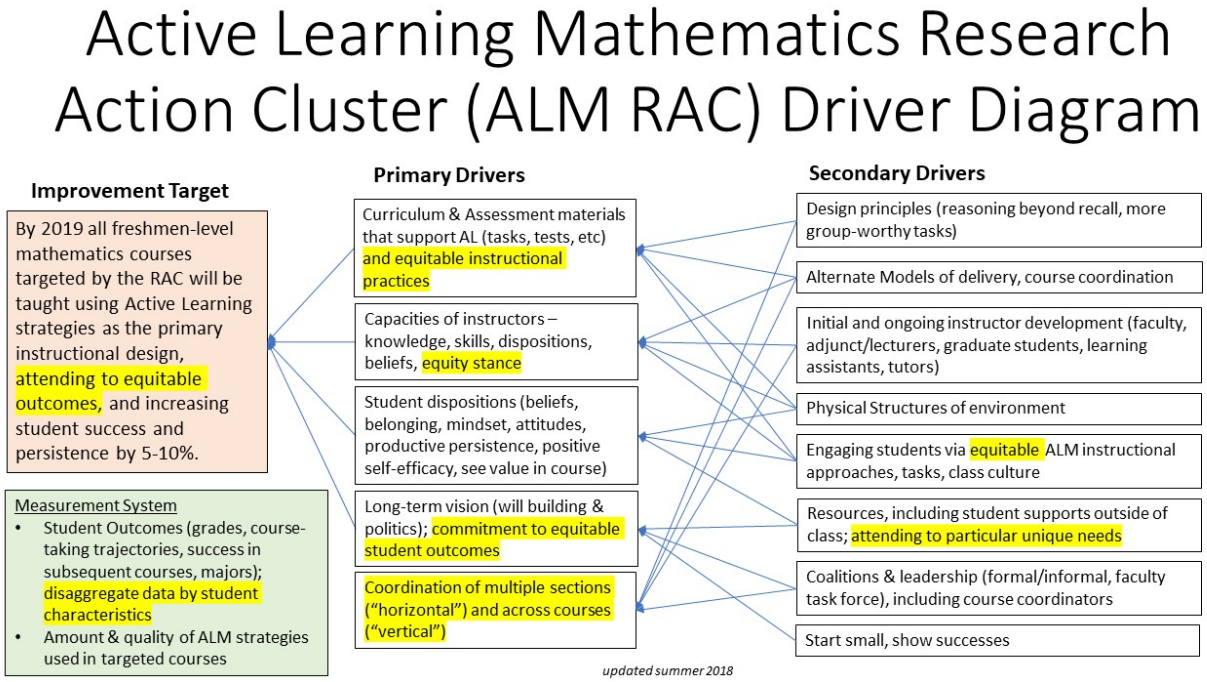

Figure 3. ALM RAC driver diagram, updated in June 2018 to add principles of equity (highlighted in yellow).

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

- Monthly meetings of the RAC members, to include some predetermined topics as well as time for sharing challenges
- Create an annotated roster of RAC membership that includes particular features of each department (such as learning assistants, graduate student training, supplemental instruction, Calculus 1 activities, etc.)
- Create and curate an online interactive library of ALM resources; such resources will include activities, tasks, assessments, data reports, etc.; we will use a Google Site, and have a Google Form that feeds data into that site.
- Identifying ways to leverage intersections with SEMINAL project resources and emergent findings
- Implementing common data collection and data analyses. Available surveys include Collegiate Active Learning in Calculus Survey (CALCS) to measure student beliefs pre/post across a semester; Post-secondary Instructional Practices Survey (PIPS) to capture instructor beliefs about mathematics teaching and learning; and Student Post-secondary Instructional Practices Survey (SPIPS), a student companion to the PIPS that can correlate student and instructor views. The ALM RAC members also utilize the Math Classroom Observation Protocol for Practices ($MCOP^2$) as a formative tool that is a basis for teaching conversations after observations. The ALM RAC also has some sample interview protocols available for learning from instructors and students.

References

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

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