
Learning Assistants' Conceptualizations of Equitable Access in Active Learning Mathematics Contexts

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Introduction

The Mathematics Academic Resource Center (MARC) within the University of Colorado Boulder (CU Boulder) mathematics department employs undergraduate learning assistants (ULAs), undergraduate tutors, and graduate student tutors to provide academic support and tutoring to students enrolled in mathematics courses at CU Boulder. The tutors working in the MARC who are not ULAs are predominantly, though not exclusively, students who are majoring in mathematics or a math-heavy science field. The ULAs are mostly freshmen or sophomores who work as assistants in active-learning lab sections of a course they have just completed as students. They also work as tutors in the MARC. Many of the ULAs have not yet declared a major. Some ULAs have entered their position because of an interest in teaching mathematics, and some develop an interest in teaching as a result of their experiences as ULAs.

This paper reports on the results of a study designed to answer the following research question: In what ways do graduate teaching assistants (TAs), ULAs and undergraduate students employed as tutors in the MARC currently conceptualize teaching for equity and access in the context of active learning classroom environments? The paper also reports on the design and implementation of a series of seminars to support ULAs and tutors in their roles working as tutors in the MARC by clarifying and deepening their understanding of how math is taught and learned, and shares insights gained during the study regarding the role of the MARC community within MARC employees' experiences in the broader mathematics community.

Active Learning Context

The work of this project is situated within the context of the CU Boulder mathematics department, which has been working to increase the use of teaching techniques consistent with design principles for active learning (Webb, 2016) and reform-based teaching. Design principles for active learning, described by Freeman et al. (2014) and explicated in detail by Webb (2016), are based on the development of an overarching mathematical coherence within a particular course, as well as specific characteristics within and across courses. Students should participate in activities which depend on the application of reasoning and sense-making skills that go well beyond recall. "Reasoning-in-process," including partially developed conjectures, explanations and representations of solution strategies" (p. 2) are valued components of desirable discourse patterns. Multiple modes of instruction are supported with a focus on eliciting peer-to-peer interaction but explicitly not limited to small-group work, and instruction should be deliberately student-centered, favoring "the perspective of the learners" (p. 2).

The CU Boulder mathematics department's change initiative has been most pronounced in the Precalculus through Calculus 2 (P2C2) course sequence, but the influence of this effort extends to numerous other courses. The primary strategy for accomplishing change has been the adoption of small class sizes and the development of "low instructional overhead" (Webb, 2016, p. 63) activities, which can be implemented by course instructors and teaching assistants with a low level of training or advance preparation. This strategy has resulted in high levels of implementation (Webb, Stade, & Grover, 2014) in the lab sessions of the P2C2 course sequence that are taught by TAs with ULAs as assistants. One impact of this strategy is that TAs and ULAs implementing these

techniques are able to do so with limited foundational knowledge in design principles for active learning on which activities are based. They may also have limited understanding of theory or effective teaching strategies to support equitable access.

Data collected for SEMINAL, a large-scale multi-institution research project, in the spring and fall of 2017 has shown significant differences between females and students of color and their white male peers on measures of positive experiences and sense of inclusion in active learning university Precalculus and Calculus courses. These results reflect students' responses to survey questions administered in P2C2 courses at six universities. Members of underrepresented groups in mathematics indicated significantly lower sense of inclusion and less positive experiences in their math classes, as compared to their white male peers (Voigt, 2017).

This finding is particularly noteworthy in light of research in active and inquiry-based learning contexts that shows numerous positive outcomes resulting from active learning. These outcomes include increased persistence to further coursework in mathematics (data collected in the Spring 2017 CALCS post survey for the SEMINAL project); significantly increased exam scores and concept inventory results, and significantly decreased withdraw and failure rates (Freeman et al., 2014); learning gains in cognitive, affective, and collaborative areas for both women and men, and an elimination of the gap between women and men (Laursen, Hassi, Kogan, & Weston, 2014). The positive outcomes are clear, but it is critical that we attend to the task of understanding why members of underrepresented groups in mathematics describe their experiences in these classes less positively than their white male peers. The results reported in this paper support the development of increased understanding of whether and how ULAs and tutors can play a role in supporting math learning experiences to be more uniformly positive for all students.

Theoretical Framing and Literature Review

Learning is understood to be socially constructed (Palincsar, 1998), and students' learning in reform-based mathematics classrooms is highly influenced by the conversations and activities in which they take part, as well as their own roles within those conversations (Yackel & Cobb, 1996). Students who participate in active learning environments, and who become central participants within those communities (Cobb, Stephan, McClain, & Gravemeijer, 2010), take up a form of mathematics learning that supports the development of a mathematics identity, or the ability to envision themselves pursuing further study in mathematics or STEM fields (Boaler & Greeno, 2000; Cobb & Hodge, 2002). Applying this theory to lesson design supports shifts toward student-centered, active and inquiry-based instruction, and ULAs have played critical roles in implementing such instructional techniques in mathematics courses at CU Boulder.

Boaler (2002) claims that reform-based mathematics teaching, of which active learning is one example, has been shown to be promising, but inconsistent in its promotion and support of equitable access to mathematics learning opportunities. Concerns have arisen in reference to the experiences of numerous historically marginalized populations including racial and ethnic minorities, females, and students from working class or lower socioeconomic status backgrounds (Ball et al., 2005; Boaler, 2002; Delpit, 1988; Lubienski, 2000; Parks, 2010). Evidence shared earlier showing variations in experiences in P2C2 courses further justifies these concerns.

Since reform-based learning experiences in mathematics have been shown to provide greater access to participation in science, technology, engineering and mathematics (STEM) communities (e.g. Freeman et al., 2014), Boaler (2002) claims that further research is needed to identify characteristics of reform teaching that support equitable access for all students in these learning communities. I suggest that ULAs could play a valuable role in shifting aspects of the learning environment in active learning mathematics courses to promote equitable access for students who are members of underrepresented groups in mathematics.

Conceptual Framing: Identity and Sense of Belonging

To support increased understanding of how ULAs and tutors can promote equitable access to mathematics, I propose considering *identity as a doer of mathematics* and *sense of belonging in mathematics* as separate constructs that together form a more robust conceptualization of mathematics identity. The Mathematical Association of America (MAA) implies such a distinction in the Instructional Practices Guide (2017) when they ask, “In what ways does this course design recognize students’ membership and positioning in society and work toward the development of positive social and mathematical identities?” (p. 123). The MAA takes up work by Gutiérrez (2009) and offers the following definition of identity: “This refers to who are our students, including the resources and ways of knowing they bring to the learning environment and who they become through their participation in mathematics” (p. 122). The phrase “who they become through their participation in mathematics,” attends to mathematics identities broadly, while referencing “resources and ways of knowing they bring to the learning environment” indicates concern for students’ ability to bring all aspects of themselves into the classroom. Students must be able to bring their personal identities with them into mathematics spaces in order to develop a sense of belonging in mathematics.

Research is beginning to demonstrate the critical role sense of belonging in mathematics has on persistence in math or science. Good, Rattan, and Dweck (2012) studied the relationship between students’ sense of belonging and decisions about whether to continue in mathematics. Analysis of results from a survey taken by 997 students (465 men and 532 women) during a Calculus course at a highly selective university in the Northeast United States resulted in the claim that “sense of belonging to math – one’s feelings of membership and acceptance in the math domain” was established as a “new and important factor in the representation gap between males and females in math” (p. 700). The work by Good et al. shows how previous work done by Hausmann, Ye, Ward Schofield, and Woods (2009) on the relationship between sense of belonging and institutional commitment applies to mathematics.

These studies make clear that students’ sense of belonging in mathematics is related to persistence in mathematics, and they begin to attend to sense of belonging as separate from identity as a person who does mathematics. The work reported on in this paper represents an effort to understand if and how ULAs can positively impact social factors in math spaces that might influence students’ development of both sense of belonging in mathematics and identity as people who do mathematics. The work has evolved to also consider the degree to which the experience of working as a ULA might contribute to the development of sense of belonging and/or a positive math identity for the ULAs themselves.

Data Collection Methods and Procedures

Data collection included of a variety of strategies designed to support increased understanding of MARC employees’ conceptualizations of teaching for equitable access in active learning contexts. Data consists of survey results, notes and one recording of interviews with MARC student employees; notes on numerous informal interviews and conversations with the MARC director; limited notes (since I was also a facilitator) taken during seminars; and field notes on observations of the MARC space. Data analysis focused on significant results that emerged in any one data source as well as themes that emerged across data sources.

The Conceptualizations of Equitable Practices for Teaching (CEPT) survey was developed and distributed to 60 undergraduate student employees of the MARC for the purpose of gaining understanding of their conceptualizations of teaching for equity and access in active learning contexts. A high response rate of almost 75% (44 students) was achieved. After removing incomplete responses there were 44 completed surveys including 27 ULAs, 14 undergraduate tutors and three front-desk greeters. The ULAs included 15 females, nine males, two

students who responded “gender diverse,” and one student who did not answer the demographic questions. Two thirds of the ULA group self-identified as “completely” or “mostly heterosexual or straight,” while 13 of 14 tutors self-identified as “completely” or “mostly” heterosexual or straight. The tutors included four females and 10 males. Both the ULA and tutor groups were approximately three-fourths white. The three front desk greeters all self-identified as white females. It is worth noting that the fall 2017 ULA group was 48% female and 45% non-white, while the fall tutor group was 25% female and 20% non-white. During the 2017–2018 academic year, the ULA group included a larger percentage of students who were members of underrepresented groups in mathematics than did the non-ULA tutor group.

Two 60-minute semi-formal interviews were conducted with learning assistants (one white female and one white male) during the Spring 2018 semester, and one 20-minute informal interview of a front desk greeter (an ethnic minority female) occurred during the Fall 2017 semester. Notes were maintained for each interview and the final interview was recorded.

The MARC director and I facilitated three two-hour seminars, two in the Fall 2017 semester, and one in the Spring 2018 semester. At least one additional seminar was facilitated by the MARC director. This seminar was not considered as part of this study. For each seminar, I noted interactions and characteristics that seemed important in the moment and wrote a brief memo after the seminars were over. During the spring semester we also maintained a Google document into which seminar participants directly entered some of their responses and ideas during discussions.

I observed the MARC space at a variety of times of day, days of the week, and times that were either immediately before a major exam or particularly quiet. Each of these observations were at least one hour and up to two hours in length. Field notes were taken for each observation. Data collection also included numerous informal conversations with the director of the MARC, which took place between late Spring 2017 and April 2018. I took notes with varying levels of detail during these conversations.

Evolution of the Seminars

The seminars designed as part of this study were intended to provide opportunities for ULAs and tutors to develop greater understanding of teaching for equitable access in active learning contexts, with a focus on their roles as MARC tutors. ULAs also enroll in a 1-credit course that supports them in developing an understanding of teaching pedagogy related to their roles as classroom assistants, but this does not address the tutoring context. It was hoped that the seminars would also foster deeper relationships among undergraduate and graduate students and help shape MARC culture to be more inclusive.

The first seminar was implemented as a large-group meeting in September 2017, and all MARC employees were required to attend. Reflection after this seminar led to the conclusion that it included too many participants to be effective, so in October 2017 a seminar focused explicitly on teaching for equity and access with a smaller group of MARC employees, which included only the undergraduate tutors and ULAs, was implemented. Attendance was optional for graduate tutors and very few attended. A significant portion of this time was focused on presentation of key ideas and large-group discussion about the terms “identity” and “sense of belonging,” as well as asset-oriented approaches to teaching and interacting with students.

This particular seminar developed an impromptu focus on mathematical conventions that grew from questions and comments raised by participants. This conversation centered on making sense of the purpose and value of conventional problem-solving methods as compared and contrasted with methods that are unconventional but mathematically accurate. The conversation remained attentive to questions about increasing participation in mathematics, and it felt productive and thought-provoking despite lack of clear consensus or

conclusions regarding the emergent questions. There were also significant imbalances with regard to who participated in the group discussion, and the ULA group participated noticeably less than the tutors.

The final phase of seminar implementation for the 2017–2018 academic year occurred in early February 2018 for an even smaller group—approximately 30 undergraduate MARC employees—including all of the ULAs for P2C2 courses, a few ULAs for other courses, and a subgroup of the non-ULA undergraduate tutors. The topics included much of the content from the fall equity-oriented session as well as discussion of emerging early semester questions and concerns. As facilitators we intentionally circulated through the room collecting and sharing out comments from participants to assure that a broad representation of ideas and experiences would be heard.

Conceptualizations of Equitable Access in Active Learning: Survey Results

The first two sets of survey prompts consist of questions about ULAs' beliefs regarding the importance of certain student perceptions. These questions ask if tutors see benefit to students believing that their ideas are valued, students believing they can get help and get questions answered, and students believing that others are encouraging them to do well in mathematics. Over 70% of ULAs and tutors responded "very important" or "somewhat important" to each of these prompts.

Both ULAs and tutors were divided as to whether "it's important for all students to participate equally during small-group discussions," but 79% of ULAs and 73% of tutors disagreed with the statement, "it's okay if a few students answer almost all the questions during class discussions." All ULAs and tutors agreed or strongly agreed with the statement, "it's important for students to receive positive or encouraging feedback on their math work." Conceptualizations of active learning and teaching for equitable access, at least to the degree these are represented by these survey responses, appear to be consistent among MARC ULAs and undergraduate tutors.

Many of the themes that emerged in seminar discussions are at least partially represented by the concern for student experience indicated in the following comment in the survey open-response question: "I am dyslexic and ADHD and I let my students know this ... so they can feel less intimidated to talk to me and ask me questions."

Varied Experiences of MARC Employees: Survey and Interview Results

My interest in the MARC community's role in the lives of those who work there grew from several factors: (1) the demographics of the ULA group, (2) the MARC director's intention to develop the MARC space as a welcoming and inclusive student community, and (3) my theory that the experience of working in the MARC might contribute to ULAs developing of a sense of belonging in mathematics, a positive mathematics identity and/or increased interest in teaching.

Early indications that the MARC might not be consistently rising to the director's inclusive vision arose in the fall seminars when the older tutor group dominated the conversation. One small group of tutors was overheard stating, "I'm a math guru," and "Yah, I'm definitely a math guru!" These comments seemed to indicate a degree of status that working as a MARC tutor could confer, but the dynamics of the seminar in which these statements were made led me to wonder if the younger and more diverse ULA group had access to this degree of status. One female third-year tutor's response to the open-response question on the CEPT survey stated, "There are some very arrogant and pretentious male tutors in the MARC who seem to intimidate and/or discourage students and other co-workers in the MARC from engaging in a discussion about math." A large and diverse set of respondents also wrote statements such as, "I really love it," and "This has been an awesome experience for me and I love that I was given a chance to LA Math even though I do have learning disabilities and Math isn't something that comes super easy to me."

Interview data from a conversation with Lisa (a pseudonym), a second-year math education major working as a ULA included a number of interesting statements. In describing her choice to pursue a math major Lisa stated, “I’m so good at it [math]” and says that she “loves math,” both of which indicate the strength of her identity as someone who does mathematics. She refers to her sense that “women in STEM are looked down on” as well as experiences such as looking around and noticing only male students in math spaces, both of which demonstrate ways that she experiences constraints on her sense of belonging in mathematics.

Analysis and Conclusions

This project has resulted in evidence that many ULAs and tutors hold views of active learning and teaching for equitable access that are likely to support positive, encouraging, and asset-oriented interactions with students in the MARC and in mathematics classes. Interactions such as these may, at least in some cases, contribute to an increased sense of belonging and positive mathematics identities for mathematics students and possibly a more robust persistence in mathematics that extends beyond P2C2 courses.

This study has also produced evidence that many ULAs and tutors in the MARC benefit from their experiences in ways that support their own sense of belonging in mathematics and positive mathematics identity, even while recognizing that the MARC community is not universally positive for all members. Work still needs to be done to improve the consistency of these experiences. The demographics of the ULA group and the fact that ULAs often either assume their roles because of their interest in teaching or become interested in teaching during their time as ULAs, points to the importance of attending to the MARC community dynamics in ways that may improve the consistency of positive experiences. The fact that ULA group includes a relatively high percentage of students who are members of underrepresented groups in mathematics means that improving the experience of being an employee in the MARC is a potential opportunity to impact the experiences of a more diverse population of participants in mathematics who may eventually become teachers.

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