Moving from Anecdote to Evidence: A Proposed Research Agenda in Community College Mathematics Education

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Introduction
AMATYC’s recently adopted five-year strategic plan, Opening Doors through Mathematics (www.amatyc.org/documents/strategicplans.htm) describes five priorities. The second of these priorities highlights the need for research on student learning. In this article, we propose a four-strand research agenda, each strand illustrated with a potential research study, offering a vision for research in community college mathematics education that connects to AMATYC’s strategic plan. In particular, we discuss the ways mathematics education research may inform our work as community college mathematics teachers. We begin by discussing the need for a research agenda while also promoting a call to action for impacting mathematics teaching and learning.

Mathematics education research has, until recently, focused primarily on issues of teaching and learning in K–12 mathematics. Over the last decade, there has been an emerging focus on questions related to undergraduate mathematics education. Although community college mathematics intersects both K–12 and undergraduate mathematics, there are phenomena specific to community college mathematics that remain under investigation. For example, one of the missions of community college mathematics is to help students obtain the knowledge and skills needed for college readiness. In some cases, community college mathematics teachers are reteaching mathematical content that students have encountered in previous mathematics courses, yet little is known about how students arrive at understanding when they are reintroduced to the content. On the other hand, some students enter our mathematics classrooms with little formal mathematics education, but with informal ways of knowing that might be unfamiliar to us. In addition, research on students transitioning from community colleges to universities, specifically those majoring in science, technology, engineering, and mathematics (STEM), can help us achieve a better understanding of the unique challenges these students face as they transition to four-year institutions. Research questions within the context of community college mathematics certainly overlap with research in both K–12 and undergraduate mathematics education, but the community college context presents itself as a unique setting worthy of investigation.

Over the past few years, researchers interested in community college mathematics education have gathered at conferences and collaborated on issues related to studying the teaching and learning of mathematics. Emerging from these discussions were ideas about various directions of inquiry-based investigations and how a common research agenda could serve as a unifying vision for researchers. To further our thinking, members of AMATYC’s Research Committee (RMETYC) hosted working group sessions at both the 14th and 15th conferences on RUME, the Mathematical Association of America’s special-interest group on Research in Undergraduate Mathematics Education. These sessions brought together more than 20 researchers and practitioners interested in investigating questions of mathematics teaching and learning in community colleges. Our goal was to outline, draft, and disseminate a research agenda to further our understanding of phenomena that are specific to community college mathematics education. The work completed during the 2011 working group session was brought to RMETYC at the 2011 AMATYC conference and the feedback obtained became the foundation for the 2012 working group session at RUME. At this meeting, we identified writing this article as a priority because of our commitment to engage more community college practitioners in classroom-based research.

In what ways might mathematics education research be useful for practitioners? Schoenfeld (2000) describes mathematics education research as serving two purposes: understanding the nature of mathematical thinking, teaching, and learning and using this understanding to improve mathematics instruction. As teachers, we often want to know the answers to
questions like “What works best in the classroom?” but this question is far more complex than it seems. Mathematics education research does not aim to answer this question because, according to Schoenfeld, “what a person will think ‘works’ will depend on what that person values” (p. 642). Instead, mathematics education research is a tool for generating knowledge about teaching and learning in mathematics classrooms, which can be used to inform the continuous improvement of mathematics education. Quality research in mathematics education has several key features: 1. it is grounded on a theoretical or conceptual framework developed from previous research, 2. the researcher employs sound qualitative, quantitative, or mixed-methods designs, 3. the researcher critically examines and reports any limitations to his or her objectivity, and 4. the findings are well documented and supported by the data. Our philosophy of research in mathematics education embraces the notion that quality research findings can be instrumental in moving forward the field of community college mathematics education in a strategic and evidence-based way.

The Four Strands of the Proposed Research Agenda

The four research strands that comprise the agenda are described below. Each description is followed by a brief example of a hypothetical research study that might be conducted under the strand. These examples include a research question, a rationale for the question, and methods for collecting data to explore the question.

Strand 1: Community College Mathematics Instruction

In this strand, we propose work that advances our understanding of mathematics instruction in community colleges. Specifically, we propose to investigate teacher knowledge and the nature of classroom interaction, seeking to define faculty development, so that mathematics instruction can support students’ learning and progress through an appropriate sequence of mathematics courses. Since this agenda focuses our attention to what is happening in community college mathematics classrooms, it is important to take a closer look at how students and teachers interact with authentic mathematics content in their classrooms.

Much has been written about the importance of involving students actively in their mathematics classes, but there are few studies in postsecondary education that explain why this is the case. In theory, allowing students to struggle with difficult problems, providing them the opportunity to discuss possible solutions and reconcile differences, and asking students to write about their thinking is beneficial for their learning of mathematics (Kilpatrick, Swafford, & Findell, 2001). However, we do not know how widespread these practices are at community colleges, whether these types of engagement are indeed beneficial for community college students, or how easy or difficult it is for faculty to engage in teaching of this kind, given the different backgrounds of faculty and students.

A possible question to guide a research study to investigate these queries might be as follows: To what extent does allowing students to struggle with difficult problems result in students learning core mathematical ideas and making steady progress in their mathematics courses sequence? This question could be addressed in any of the types of courses offered at a community college, adding depth to our findings.

Data would be collected systematically, analyzed, and the findings evaluated in terms of students’ learning and progress. Examples of data that might be collected to answer the research question include video recordings of a representative number of lessons taught by community college faculty who already use difficult problems in their lessons, pre- and post-tests of their students to determine gains, interviews with students to ascertain their level of understanding of the content, and interviews with the faculty to learn how they organize their teaching. Perhaps there are students who benefit more from working difficult problems and confirming this hypothesis would be beneficial. In addition we might want to learn more about teachers. For example, have teachers who have implemented these changes in their practice received a special kind of training? Does prior teaching or work experience makes a difference? Do teachers’ attitudes towards mathematics determine their instructional practice? Finally, it would be important to collect data in many classrooms, with many teachers and their students, and with campuses having different characteristics. This depth and breadth of data would augment the robustness of the findings.

Strand 2: Community College Mathematics Students

In this strand, we propose the three areas of work that seek to create a knowledge base of students in community college mathematics classrooms: community college students’ understanding of mathematical notions, their attitudes and motivations, and their expectations of mathematical work. It is essential to understand the students who are taking our classes in order to capitalize on their strengths and provide adequate support to overcome the challenges they encounter as they progress through mathematics courses.

Much has been written about the number of underprepared students arriving in community college developmental mathematics classrooms (Bailey, 2009; Shore & Shore, 2003; Stigler, Givvin, & Thompson, 2010). As a result, many well-intended reforms have been implemented in community college mathematics with mixed success. Despite these efforts, success in developmental mathematics remains elusive for many students. Previous research in this area has focused on failure or disappearance rates (Bailey, 2009; Stigler, et al., 2010),
typically relying on institutional data with scant attention paid to the experiences of the students in these classrooms (Grubb, 2005). There are calls within the mathematics education community for more studies of student success rather than a continued focus on disparities (Cobb & Hodge, 2002; Lubinski & Gutierrez, 2008). Many underprepared students do persist and succeed in community college developmental mathematics courses. A study of students who successfully proceed through their mathematics courses would provide essential understandings to support instructors in fostering productive mathematical dispositions (Kilpatrick, et al., 2001). A question to guide a study to investigate this query might be: What are the characteristics of students who progress from developmental mathematics to college level courses and what obstacles did they overcome?

Interview data would be collected to explore this question with students who have completed developmental mathematics and are ready for college-level mathematics. Interview questions would address students’ experience in the classroom both with respect to the types of activities in which they took part, as well as their experience of the curriculum. The interviews would also include questions about students’ attitudes about these experiences and the relationship between their classroom experiences and their motivation to persist in the mathematics course sequence. The analysis of data would be geared to uncover common themes about what contributes to students’ unsuccessful and successful mathematics experiences. In addition, a survey instrument could be developed from the common themes and used for larger scale quantitative studies in order to generalize the findings from the interview data. With such findings, instructors might define classroom characteristics and instructional strategies conducive for success.

**Strand 3: Community College Mathematics Curriculum**

This strand proposes work on different levels of curriculum (intended, implemented, and achieved), including the organization of mathematics programs, the sequencing of topics within mathematics courses, and the implementation of curriculum in the classroom and its connections to students’ learning.

On a programmatic level, a variety of pathways to college-level mathematics is being developed and it will be important to examine students’ success in these programs and their experience of these alternate curricula. However, introductory and intermediate algebra advancing toward college algebra has been the predominant pathway for many years, but there is no clear definition of the curriculum for this particular path. A significant body of research (Carlson, Jacobs, Coe, Larsen, & Hsu, 2002; Oehrtman, Carlson, & Thompson, 2008; Thompson, 1994) has identified proportional reasoning, ability to reason with rates, and understanding of function as essential for a student to be successful in precalculus and calculus courses. A question we might pose is as follows: Does the precollege algebra curriculum support the development of these essential understandings?

Several types of data would be collected to address this question. First, a content analysis of common textbooks used in the precollege algebra sequence would be undertaken, focusing on the presentation of proportional relationships, rates, and functions. Next, descriptions of introductory and intermediate algebra courses offered at a representative sample of community colleges would be collected in order to determine characteristics common to these courses, as well as distinguishing characteristics. These two sources of data would help us understand the intended curriculum for these courses. Using an appropriate sampling method, we would then interview teachers about how they teach these topics, use their textbooks, and help students develop these ideas. These data would provide an understanding of the enacted curriculum. Findings from a study like this would help faculty both define and refine the precollege algebra curriculum based on the development of students’ understandings necessary for success in college level course work.

**Strand 4: Technology and Mathematics e-Learning in the Community College**

This strand proposes work that seeks to understand the role and impact of technology—in particular, classroom technologies (e.g., graphing calculators, computer algebra systems, spreadsheets, mobile applications, clickers), online homework systems (e.g., Pearson’s MyMathLab/Mastering), systems for course management and assessment (e.g., Blackboard, ALEKS, Moodle, Canvas), and online distance education—in mathematics teaching and learning. These technologies are becoming a mainstay in mathematics classrooms yet little is known about the extent to which they enhance mathematical learning or how they affect the nature of students’ learning. Research emanates primarily from the university level with far less attention to community college settings. However, given the documented usage of the above technologies at two-year colleges (Andersen, 2001; Lutzer, Rodi, Kirkman, & Maxwell, 2007) and the uniqueness of the community college student, there is a need to examine how the infusion of these technologies affects mathematical learning in this context. Clearly, this strand does not stand in isolation as it influences what mathematics is taught as well as how it is taught. Therefore, it is important that we propose meaningful questions that inform practice but not to the point of failing to capture the qualities of what precisely makes an effective e-learning environment.

Given the broad scope of this strand, a research proposal for a specific technology is outlined—namely, computer algebra systems (CAS) in mathematics classrooms. At the
university level, significant work has been done on the use of CAS. Researchers have focused on the impact of CAS on technical and conceptual knowledge. Two important findings have proved to transcend grade level and ability level: CAS use does not generally weaken students’ abilities to perform routine procedures in mathematics (Heid, 1988; Hillel, Lee, Laborde, & Linchevski, 1992) and students’ conceptual growth and understanding are not lessened by CAS usage (Heid, 1988). Currently, we know little about how two-year college students use CAS or how their understanding may mold (and be molded by) such tools. CAS is far more than a “black box” computing environment and it is the development of understandings in CAS environments and the complexities/co-dependencies of these understandings that are particularly relevant.

A question that may provide insights into the above might be: How do the mathematical understandings of students evolve and intertwine with usage of CAS and what is the nature of this learning? Data collection for this investigation would be multifaceted. For example, given tasks suitable for CAS environments, researchers could examine the work done by students by making inferences from CAS logs. Such examination could be validated with interviews with students on the strategies employed—whether the strategies were influenced by technology use or not, and the nature of this influence. Moreover, a systematic examination of student actions based on the feedback from CAS would shed light on students’ thinking. Although similar work has been carried out in recent years by Kieran and Drijvers (2006), the specific focus of their work (secondary-level algebra students) warrants investigations into similar phenomenon at the two-year college level.

CAS has the potential to press questions about what mathematics we should be teaching in classrooms. As CAS can fluently perform routine procedures minus the drudgery, we need to bring the enactors of curriculum into the conversation. Finally, there are concerns of equity in mathematics classrooms whenever technology is the centerpiece (Dunham & Hennessy, 2008). Requiring use of such technologies may exacerbate the already existing inequities in education. Concerns such as these are quite real in community colleges and it would behoove us as a community to initiate more dialogue from all affected parties.

Discussion
Conducting research in our classrooms will further our understanding of mathematics teaching and learning in community college classrooms, but it poses several challenges as well. Allowing one’s class to be recorded not just once but several times might be difficult for teachers and students alike; making time for answering surveys or participating in interviews, or using class time for collecting student survey and learning data might make faculty skeptical about taking part in these studies. It is important to have in mind, however, that compared to medical research, for example, the research procedures outlined here are less invasive and are designed to benefit participants. Faculty can use pretests results to modify instruction and could use data from student interviews to design lessons to address specific mathematical difficulties in their classrooms. Students can also be alerted to their own weaknesses so they can take proactive roles in learning specific topics. Would this ‘contaminate’ the findings? Members of the research community might say ‘yes,’ but we and our students are in the enterprise of teaching and learning; we constantly use information from students to improve our practice and students use our feedback to further their learning and progress.

How can we benefit from research studies such as those outlined here? Assume for a moment that we can demonstrate that there are important gains on students’ learning or in their confidence about themselves as learners of mathematics. Say, for example, that we could replicate findings from the literature about at-risk students benefiting from instruction that allows students to struggle with difficult problems. The next steps for colleges, departments, and faculty would include designing strategies that could be used to support instruction for at-risk students to learn mathematics and proceed through an appropriate sequence of mathematics courses. Such strategies could then be used as models by other colleges, departments, or institutions, which would then engage in assessing whether such teaching is as beneficial for other types of students on their campuses.

Conclusion
This proposed agenda aligns with priority two of AMATYC’s strategic plan—Promote research on student learning in two-year colleges. All the studies outlined under the proposed research agenda focus on student learning, but also support several of the bulleted items that fall under this priority: 1. advocate for the continued improvement of textbooks and other instructional resources based on lessons learned from classroom research, 2. advocate for faculty, departments, and colleges to institute innovative practices informed by research, and 3. disseminate resources and best practices on teaching and learning to facilitate faculty development. In conjunction with AMATYC’s strategic plan, the authors of this article call for a concerted effort by researchers to produce high-quality research based on a coherent agenda that facilitates the development of a robust understanding of the teaching and learning of community college mathematics. Research focused on the proposed strands of the agenda will contribute to the field of mathematics education and support faculty in making informed
decisions about curriculum, instruction, and students at our community colleges.

Collaboration and communication between community college faculty, faculty-researchers working at community colleges, and university mathematics education researchers are essential for moving this research agenda forward and for continuing the conversation about the ways practice informs research and vice versa. We recognize the value of classroom-based research conducted by individual teachers. More often than not, however, this work produces anecdotal data with non-representative samples. We must work together on a common agenda to capitalize on a systematic approach to research, teaching, and learning that can bring coherence and usable knowledge for our practice.

References


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