Research Problems in Community College Mathematics Education: Testing the Boundaries of K–12 Research

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The purpose of this commentary is to articulate the need to investigate problems of mathematics instruction at community colleges. We briefly describe some features of this often-ignored institution and the current status of research. We also make an argument for how investigations of instruction in this setting can both advance our understanding of this particular context and give practitioners tools to deal with pressures from policy makers to show short-term results. This work is the result of a collaborative effort between community college practitioners and researchers, responding to the needs of their work in mathematics education.

Key words: Community colleges, Student success, Instruction, e-learning

We express our deepest thanks to the participants in the two working groups on community college research at the Research in Undergraduate Mathematics Education annual meetings in Portland (2011 and 2012) and to the organizers for facilitating these conversations. We also thank David Bressoud, Tatiana Melguizo, Vanessa Morest, Ricardo Nemirovsky, Chris Rasmussen, and Mike Shaughnessy for comments on some of the ideas presented here. This material is based upon work supported by the National Science Foundation under Grant No. DRL 0745474. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

This is an Accepted Manuscript of an article published by the National Council of Teachers of Mathematics in the *Journal for Research in Mathematics Education* in March 2014, available online: http://www.nctm.org/Publications/journal-for-research-in-mathematics-education/2014/Vol45/Issue2/RESEARCH-COMMENTARY_-Research-Problems-in-Community-College-Mathematics-Education_-Testing-the-Boundaries-of-K%E2%80%9312-Research/.

About 45% of all current college students (Aud et al., 2011; Dowd et al., 2006), about 53% of all college freshmen (United States Census Bureau, 2012), and about 49% of all mathematics majors (Rodi, 2007) in the United States are currently enrolled at a public two-year college. In addition, many of the students currently enrolled at four-year institutions previously attended community colleges: 45% of students who graduated from a four-year college during the 2010–2011 school year at one point attended a community college (National Clearing House, 2002). National attention to community colleges has provided a necessary spotlight for investigating mathematics education. President Obama's (2010) White House Summit on Community Colleges was preceded by a flurry of papers related to community college mathematics (e.g., Bailey, 2009; Rosenbaum, Stephan, & Rosenbaum, 2010), yet authored by people outside the field of mathematics education research and with little to no experience teaching mathematics at community colleges (Gonzalez, 2010; The White House, 2011). Most of the scholarship on community college mathematics education is conducted by higher education scholars, and it concerns the costs of remediation or student retention and success, with success somewhat narrowly defined either as passing courses or as completing a college degree (see e.g., Attewell, Lavin, Domina, & Levey, 2006; Bahr, 2008; Bailey, Jeong, & Cho, 2010; Dougherty & Hong, 2006; Melguizo, Hagedorn, & Cypers, 2008). This scholarship leaves unexplored the one aspect that may most determine students' success: their experiences in the mathematics classroom (Mesa, 2007). In this article we provide a different definition of student success: Student success is to be understood as composed of two possibly interrelated aspects: students' learning of the material and students' steady progress towards accomplishing their academic goals. We argue that the current state of affairs regarding scholarship on community college mathematics education should be a main concern for mathematics education scholars. The community college is a context in which our current knowledge of “what works” can be contested.

Distinguishing Characteristics of the Community College Mathematics Classroom

The field of mathematics education has made substantial strides in advancing our understanding of teaching and learning, but there is work to do as we seek to use what we know in specific settings (e.g., community colleges, special education, undergraduate education) that are different from those in which the research was originally conducted. As practitioners and researchers at community colleges, we deal with continuous misunderstanding among our non-community-college-based colleagues about the needs, abilities, and sociocultural perspectives of our students; about the characteristics and culture of our faculty; and about the ethos, organizational structure, and mission of our institutions. Each of these three factors has important implications for conducting research in this setting.

Students

Historically, community colleges have assumed four missions: (a) academic transfer preparation, (b) terminal vocational certification, (c) general education leading to an associate’s degree, and (d) community education—all of them seeking to accomplish the diverse aims of democratic equality, social mobility, and social efficiency (A. M. Cohen & Brawer, 2008; Labaree, 1997). Shifts in economic organization have added a fifth mission—retraining workers for a changing economy—that seeks to fulfill a social efficiency aim.

Unlike other higher education institutions, community colleges operate with open access policies and low to moderate selectivity (Altbach, Gumport, & Johnstone, 2001; Clark, 1960; A. M. Cohen & Brawer, 2008; Fairweather, 1996; Shaw & London, 2001). This generates classrooms in which the majority of the students are underprepared and under resourced, have family or work obligations, and have different goals and intentions regarding the completion of their degrees. In addition, community colleges have high concentrations of English language learners and students with identified physical and cognitive disabilities (Goldrick-Rab, 2007).

One might suppose that some of these differences are just artifacts of community colleges being public institutions, or of their role as institutions that enroll only students completing their first two years of college, but these differences persist even when comparing only first-year students enrolled at any public institution. In this comparison, community college students are significantly more likely to have high-risk characteristics (i.e., delayed enrollment, no high school diploma, part-time enrollment, financial independence, dependents, single parent status, working full-time while enrolled; see Goan & Cunningham, 2007; U.S. Department of Education & National Center for Education Statistics, no date) than students at four-year institutions. The greater the number of these risk factors, the higher the likelihood that a first-year student is enrolled at a community college rather than a public four-year college or university. Furthermore, first-year community college students are significantly more likely to be non-white, to have a disability, to be first-generation college students, to have incomes below the poverty line, to have a low high school grade point average, and to have taken no upper-level mathematics courses in high school in comparison to first-year students at public four-year colleges or universities (Goan & Cunningham, 2007; U.S. Department of Education & National Center for Education Statistics, no date).

The bulk of remedial coursework takes place at community colleges. In 1995, the number of students taking a remedial mathematics course at a four-year college or university was 222,000; ten years later, that number dropped to 201,000, to rise again to 334,000 in 2010. The figures for two-year colleges were 799,000 in 1995, 964,000 in 2005, and 1,150,000 in 2010.

That is, two-year colleges enroll almost four times as many remedial mathematics students as other institutions of higher education (Rikki Blair, Kirkman, & Maxwell, 2013; Lutzer, Rodi, Kirkman, & Maxwell, 2007)[1]. Although developmental coursework is not the only feature of the community college environment that sets it apart from other institutions of higher learning, it is a key part of what must be studied if we are to understand the learning and educational trajectories of community college mathematics students.

Community college students also differ dramatically from K–12 students, even though there is overlap in the mathematical content knowledge taught in both contexts. Compared to K–12 students, community college students tend to be financially independent, enroll on a part-time basis, be employed full time, and have dependents (Goldrick-Rab, 2007; Mesa, 2012); they may be more likely to see class attendance as something that may directly further career and personal goals than high school students. In addition, community college students are more likely to have had a gap in formal schooling and are often relearning material to which they were previously exposed in the K–12 environment or in their work (Grubb & Kalman, 1994). Community college students often need to unlearn deep-rooted misconceptions about mathematics built from previous (mostly negative) experiences and reconcile their "real-world" experiences with these concepts as they may clash with the academic presentation done in the classroom.

Faculty

The faculty at community colleges differs in key ways from K–12 teachers and from other higher education faculty. As a group, faculty at community colleges are more likely to come from traditionally underrepresented groups than faculty at four-year colleges and universities.

[1] These figures should give us pause if we were to think of them as a metric for the success of K-12 mathematics education.

Community college faculty are significantly more likely to have a disability, to be female, or to be an ethnic minority that is underrepresented in science, technology, engineering and mathematics fields (e.g., American Indian/Alaska Native, Black, or Hispanic; see Cataldi, Fahimi, & Bradburn, 2005). This may impact the classroom environment and the institutional culture, for example by changing the ways in which *stereotype threat*[2] or *implicit bias*[3] play out in mathematics classrooms at institutions where many faculty and administrators (in addition to many of the students) come from minority groups. Research has shown that the composition of the classroom and the demographics of persons in positions of authority can affect the extent to which stereotype threat and implicit bias are present and the ways in which they are experienced (Steele, 1997, 2011; Steele & Aronson, 1995).

Another important feature relates to the proportion of mathematics faculty at community colleges who are employed on a part-time basis. The average ratio of part-time to full-time faculty in mathematics departments at two-year colleges in 2005 was 2:1, whereas it was 1:4 at four-year institutions (Rikki Blair, et al., 2013, p. 33). This ratio has been increasing at community colleges over time, and it is predicated on the need to accommodate for fluctuations in student enrollment. High ratios, however, might be detrimental to students' graduation rates at community colleges. Indeed, using national data, Jacoby (2006) found that increases in the ratio

[2] *Stereotype threat* (Steele & Aronson, 1995) refers to a state in which one is at risk of reinforcing negative stereotypes about one's own group (e.g. blacks, women) through one's own behavior or performance. This "threat" of reinforcing negative stereotypes can lead to significant drops in performance on a task associated with that negative stereotype. For example, the stereotype threat explored in Steele and Aronson's original article occurred when black college students were given standardized tests: the performance of black students on these tests was poorer when their race was emphasized versus when it was not, particularly when the test was presented as an accurate measure of intellectual ability.

[3] *Implicit bias* (Greenwald & Banaji, 1995) is a type of unconscious bias possibly based on a set of beliefs that is in direct opposition to one's consciously held beliefs. For example, even if we consciously believe that both men and women are equally competent at math, we may be surprised by the mathematics performance of a woman relative to that of a particular man because of we are unconsciously internalizing the belief that women are less competent at math.

of part-time to full-time faculty at community colleges has a negative impact on three distinct measures of graduation rates: the graduation rate (as collected in the Integrated Postsecondary Education Data System), the net graduation rate excluding transfer students, and the overall degree ratio (see pp. 1090–1092). Other accounts, however, indicate that faculty status has no association with course completion in developmental mathematics education (Fike & Fike, 2007).

Finally, and most importantly, faculty in community colleges are typically not expected to conduct research but to concentrate on *teaching* (Grubb, 1999). Community college faculty carry heavy teaching loads (e.g., 4 to 6 courses for an average of 15 credit hours per term for full-time faculty) and more demands for performing administrative work. This difference can contribute strongly to differences in institutional culture. For example, Astin (1993) found that strongly research-oriented institutions had higher rates of student dissatisfaction and lower student scores on most measures of cognitive and affective development, including college GPA and bachelor's degree completion, whereas institutions that were strongly oriented toward student development had higher rates on these measures.

We note that this is an institution-level effect, not a faculty-level effect, as other research has consistently shown that faculty research has little correlation with teaching outcomes (see e.g., Hattie & Marsh, 1996 for a meta-analysis). However, what this research illustrates is that an institution's orientation towards research and teaching can significantly impact student experiences in the classroom and student educational outcomes. Because the research and teaching orientation of community colleges is typically quite different from the majority of four-year institutions, we can anticipate different classroom dynamics and different teaching and mentoring cultures, and it is legitimate to investigate the extent to which these differences matter.

~~**Culture**~~ It is not just the distinct characteristics of community college students and faculty that make the community college context an important setting for research. The classroom and institutional cultures of community colleges and four-year schools are also distinct in ways that have not been adequately explored, but which may impact student outcomes in ways that may be explained through a number of different theoretical lenses (such as *relative deprivation*, *motivation*, and *academic integration*) that have already been used in other contexts. Research in higher education has documented that institutional context can make a significant difference in student outcomes. For example, Sax (1994) found that there were particular features of the environment at more selective institutions that had a significant negative impact on mathematics self-concept for women, perhaps because "women might be more strongly affected than men by a sense of *relative deprivation* with respect to math ability[4]" (p. 125). In the Sax study, at more selective institutions, women showed larger declines in mathematics self-confidence from college entry to exit than did men (whereas the declines were similar for both sexes at less selective institutions); and after controlling for initial student ratings of mathematics self-confidence, two institution-level factors associated with higher selectivity (higher levels of competition among students, higher proportions of men enrolled) both correlated significantly and negatively with gains in mathematical self-confidence throughout college for women, but not for men. Other studies in *motivation* of remedial students in mathematics suggest that there is a stigma associated with being enrolled in remedial courses at four-year colleges (Hall & Ponton, 2005), yet this seems not to be the case for students in remedial courses in two-year institutions

[4] *Relative deprivation* (Stouffer, Suchman, DeVinney, Start, & Williams Jr., 1949) occurs when an individual subjectively perceives that she or he has less of some particular advantage in comparison to a reference group which is perceived as having similar attributes. The theory of *relative deprivation* would suggest that at more selective institutions (where other students have stronger mathematical skills and backgrounds), students may be more likely to choose lower ratings for their own mathematical abilities (because they are lower relative to their peers at that) institution than they would be to a larger population average, or to the average abilities at a less selective institution.

(Mesa, 2012). Other theories, for example *academic integration* (Pascarella & Chapman, 1983; Tinto, 1987; Umoh, 1994), have been shown to operate differently in community college settings, where external factors are more likely to play a major role in influencing nontraditional students, compared to four-year contexts (Bean & Metzner, 1985).

Despite these clear differences between community college and university students, faculty, and institutional cultures, little research in postsecondary mathematics education has been conducted with this population. Instead, most research attention has focused on doctoral and research universities, which comprise only 7% of all postsecondary institutions, whereas community colleges represent 37% of postsecondary institutions (Burton, 2007; National Center for Education Statistics & Institute of Education Sciences, 2012).

Community College Mathematics Education: What do We Know?

An analysis of the literature on community college mathematics teaching and learning revealed three distinct bodies of research: studies conducted by researchers in higher education, studies conducted by community college practitioners, and studies conducted by adult education researchers. Researchers in higher education, who ask questions about retention, success, cost, faculty, and duration of programs, produce the first body of research. Questions of teaching and learning in particular subject areas are not part of these scholars' inquiry. Concerns with learning appear to be described in general terms, as in critical thinking, problem solving, or being able to work in collaboration with others (Arum & Roksa, 2011), and are not well defined for the most part. Remediation has been an important focus of attention in this scholarship (Levin & Calcagno, 2008; Perin, 2004). Most of this work is meant to inform institutional organization such as admissions, financial aid, and advising offices as well as other sources of student support (e.g., learning centers, computer labs, funding or other incentives). Unsurprisingly, these studies have conflicting operational definitions of mathematics instruction. Mathematics teaching refers to either the mathematics courses students take, the grades they obtain in those courses, or to the frequency with which teachers use instructional pedagogies (e.g., technology, writing projects). None of these definitions attend to the work of students and teachers inside the classroom as they learn specific mathematics content (Mesa, 2007).

Practitioners who want to improve students' experiences in the classroom produce the second body of research. These studies propose specific interventions such as new ways of using technology, ways to manage anxiety, or re-sequencing topics (see, e.g., Craft & Mack, 2001; Jones, 2001; Vejdani-Jahromi, 1994) and utilize data at the classroom level to test the effectiveness of the intervention. These studies have a narrow scope, and they are meant to inform practitioners rather than researchers. For the most part, these studies (see e.g., Best & Fung, 2001; Hagedorn, Sagher, & Siadat, 2000; Katsutani, 2001; Marshall & Reidel, 2005; Villarreal, 2003) have methodological problems that limit the possibility of replication, including: lack of clearly articulated theory, small non-random samples, use of measures that are not well defined, or lack of descriptions of how instruction is organized.

The adult education community produces the third body of research. Of 41 papers published in *Adults Learning Mathematics*, a journal started in 2000, four articles (Gill & O'Donoghue, 2007; Khazanov & Prado, 2010; Maciejewski, 2012; Mesa, 2010) relate to community college teaching or classroom work. Most papers deal with adults' beliefs, attitudes, and anxieties towards mathematics or with workplace mathematics rather than with how instruction happens. Four studies in this journal (e.g., Ashun & Reinink, 2009; Hauk, 2005; Mesa, 2010; Viskic & Petocz, 2006) have university or community college students in their samples. Adult numeracy and literacy and vocational preparation are important themes for this community and includes work from other countries (e.g., United Kingdom, the Netherlands, Australia). An analysis of the proceedings of the Annual Meeting of the Adult Learning Mathematics group since 2000 yielded 204 paper presentations, of which about a third dealt with teaching or instruction (63 papers), but only 17 (8%) explicitly indicated that there were classroom observations; seven (3%) had a community college setting, and only two (1%) dealt with instruction of postsecondary students (Kantner, 2008; Peskoff & Khazanov, 2006). Most of the papers were descriptive, and only a few were empirical. A review conducted to identify current research and practice on adult numeracy instruction, assessment, and professional development that would be worthy of replication revealed that:

> The little research to date has not addressed [the effects of numeracy instruction, assessment, or professional development on adults] . . . in any organized way. The limited research identified—15 studies of ABE [Adult Basic Education] students and 9 studies in developmental mathematics—seems like guerrilla warfare far more than an organized victory campaign toward improving adult numeracy instruction (Condelli et al., 2006, p. 61).

The impression that we get by looking at the current literature on community college mathematics education has the same feel of disorganized guerrilla warfare. The current pressure for accountability (Rothkopf, 2009) pushes institutions to implement programs that are marketed as increasing student success (e.g., personalized learning) but most of these programs are borne out of political pressures to demonstrate better outcomes, with outcomes weakly defined as completing remedial work, persistence from one semester to the next, or earning a degree or certificate (see Rothkopf, 2009). In sum, we, community college practitioners and researchers, see a major problem: a lack of organization of research efforts, which hinders the possibility of using what we know for improving practice or to influence policy. We see teaching as a crucial aspect for organizing our collective effort (Condelli, et al., 2006) not only because instruction is the core mission of community colleges but also because recent work on teaching suggests that high quality instruction can support gains in student learning (Antoniou & Kyriakides, 2013; Creemers & Kyriakides, 2012). By prioritizing research on instruction and aligning other key areas of research around it, we believe we can canalize efforts in ways that can be more productive in the long run for building a robust knowledge base about what works in community colleges.

The Community College as a New Research Frontier: "Pushing the Boundaries of the Problem Space"

> *One makes progress by systematically pushing the boundaries of the problem space in order to see where the theory "'breaks.'".* That is, it is essential to choose cases for analysis that you think you might be able to understand and that have the following property: If you succeed in explaining them, you will have expanded the scope of the theory, and if you fail, you have found a limitation of the theory. (Schoenfeld, 2010, p. 105)

This excerpt from a research commentary published in this journal supports our argument for a research agenda that addresses problems that, although not unique to community college mathematics education, have particular manifestations in this context. We propose that research efforts be aligned in four areas: instruction, students, curriculum, and technology use and e-learning.[5] These four areas emerged from discussions held in two RUME working groups that

[5] We use the term e-learning to refer to the use of electronic and distance technology in education. With this term we also seek to encompass synchronous and asynchronous communications and in- and out-of-classrooms use of technology.

gathered practitioners, researchers in mathematics education, and researchers in higher education to a discussion about research in mathematics education at community colleges (see Appendix). The four areas that we selected, were meant to encompass a wide range of work centered on what is crucial for teachers; we sought internal coherence (by organizing the areas along the elements of the definition of instruction) and building upon—pushing the boundaries—of the work done in K–12 mathematics education (and in post-secondary education). The first three areas were selected because we care primarily about the processes of teaching and learning of mathematics within classrooms. The last area was chosen because it is a rapidly growing mode of instruction that has not been as well researched as the face-to-face environment. Other areas could have been chosen (and were part of earlier drafts). The inclusion of assessment, for example, was extensively debated. Yet, the consensus was that for practitioners, more immediate questions about their teaching were more pressing. Although knowing about assessment is important, we first needed to learn how mathematics teaching and learning happens at our community colleges, as we saw that knowledge as providing us with better leverage for further investigations—including those on assessment. We acknowledge that these areas will evolve over time, as "conditions on the ground" evolve, and we look forward to these evolutions.

In Sitomer et al. (2012) we provided some examples of practitioner-led research that could be carried out under this proposed agenda, and we refer the reader to that article. In this commentary, we briefly describe research on instruction, students, and curriculum, and provide an extended elaboration on the area of e-learning.

College Mathematics Instruction

We define instruction as the interaction between teachers and students with authentic mathematical content, embedded in particular environments and evolving over time (D. K.

Cohen, Raudenbush, & Ball, 2003). Authentic mathematical content includes not only mathematical concepts, algorithms, and skills, but also the disciplinary practices of problem solving, modeling, and reasoning (Rikki Blair, 2006; National Council of Teachers of Mathematics, 2000). By reasoning we mean constructing and evaluating both mathematical and statistical arguments, defining, axiomatizing, conjecturing, proving, and describing or using mathematical structures (Rasmussen, Zandieh, King, & Teppo, 2005).

It is during the day-to-day work in the classroom that all aspects of instruction coalesce to create opportunities for students' learning. This definition allows us to investigate instruction by attending to either individual elements—teachers (what they say, think, and do for planning, enacting, and assessing instruction), students (what they say, think, and do that reveal how and what they learn), mathematics (the tasks that are chosen, how content is organized, presented, and sequenced) and environments (how they influence what happens in the classroom)—or to the combination of all these elements.

With regard to mathematics instruction at the community college level, we propose to investigate the connection between teacher knowledge, the nature of classroom interactions, and student learning and success. We ask, is the mathematical knowledge for teaching elementary mathematics to children (Ball, Thames, & Phelps, 2008) sufficient to characterize the mathematical knowledge for teaching needed for teaching elementary mathematics to students in community college settings? What do we learn about mathematical knowledge for teaching elementary mathematics to children by studying the construct with faculty responsible for teaching community college remedial students? As a byproduct, we anticipate substantive work designing faculty development that can support the teaching of authentic mathematics content for community college students. Similarly, we ask whether the models of professional development that appear to be very common for developing teachers in schools will apply with faculty at community colleges. Given the working conditions and the other characteristics described earlier, we need to know what should be the emphasis of these models, the most effective mode of delivery, and the best ways to ensure accountability. For other examples, see Sitomer et al. (2012).

Community College Mathematics Students

Student success is to be understood as composed of two possibly interrelated aspects: students learning the material that teachers and departments intend them to learn and students making steady progress towards accomplishing their academic goals. By separating learning from progress we can attend to different and important elements of students' experience in postsecondary education. Given our definition of authentic mathematical content, our vision of student learning of mathematics requires students to demonstrate mathematical proficiency in the five strands described in Kilpatrick, Swafford, and Findell (2001): procedural fluency, conceptual understanding, strategic competence, adaptive reasoning, and productive disposition (p. 5). We see student proficiency in these areas as fundamental for demonstrating learning of authentic mathematical content. The second element of success, progress, refers to passing the courses that students take as required to achieve their academic goals.

Research is needed to augment our knowledge base on community college students' understanding of mathematical notions, their attitudes and motivations, and their expectations of and dispositions towards mathematical work in a community college classroom. Rather than proposing general characterizations of community college mathematics students, like most studies available today, we seek to understand better their *mathematics* learning trajectories. For example, do adults follow similar learning trajectories as children when learning about fractions (or other mathematical topic taught in school mathematics)? What are typical mathematical misconceptions that community college students (including adults who have had a gap in schooling) possess, how do these misconceptions manifest, and how do they change as students engage in learning remedial mathematics? See Sitomer et al. (2012) for other concrete examples that illustrate that current ways of thinking about student mathematics learning are insufficient for understanding community college students' mathematics learning.

Community College Mathematics Curriculum

In the area of curriculum, we propose work on different levels (intended, implemented, and attained, see examples in Sitomer et al., 2012), 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 are being developed, and it will be important to examine students' success in these programs and their experience of these alternative curricula. Current initiatives to reorganize the community college mathematics curriculum (e.g., the Carnegie Foundation's programs Quantway and Statway, and the American Mathematical Association of Two-Year Colleges (AMATYC)'s New Life Project) are in early stages of implementation and findings on their impact will take time to emerge.

Mathematics e-Learning in the Community College

This strand does not stand in isolation from the other three areas of proposed research, as it is closely interrelated to *what* mathematics is taught, *how* it is taught, and to *whom*. Elsewhere (see Sitomer et al., 2012) we have argued that technology poses interesting challenges for the community college mathematics instructor, as it encompasses a wide range of possibilities:

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 e-learning education in mathematics.

E-learning is becoming a prevalent mode of instruction, especially in community colleges. About 60% of community college students take at least one course online (Pearson Foundation, 2010), with online enrollments growing about ten times faster than higher education enrollments generally (Allen & Seaman, 2011). Lutzer, Rodi, Kirkman, and Maxwell (2007) reported that when compared to four-year institutions, two-year institutions offer more distance learning courses in calculus and statistics.[6] Indeed, less than 1% of sections of calculus and statistics sections are offered in distance learning modality in four-year institutions, compared to over 5% of sections of calculus and 8% of sections of statistics at two-year colleges. Online settings in community college mathematics classrooms can provide a fertile ground for investigation.

Little research exists focusing specifically on the community college population, but what research is available in this area suggests that online coursework may actually hinder student persistence and degree completion. Studies and meta-analyses show no strong positive or negative effect on learning outcomes in terms of exams or course grades (Bernard et al., 2004; Bowen, 2012; Bowen, Chingos, Lack, & Nygren, 2012; Jaggers, 2011; U.S. Department of Education, 2010). Rather, the issue seems to be that a larger proportion of students withdraw from online courses than face-to-face courses: Drop-out rates in online courses range from 30–

[6] Distance learning courses are defined by Lutzer and colleagues as those in which at least half of the students receive instruction in a situation in which the instructors is not physically present (Lutzer, et al., 2007, p. 76).

40% in the U.S. (Tyler-Smith, 2006), consistently 10–20 percentage points higher than those for face-to-face classes (see, e.g., Hachey, Wladis, & Conway, 2013; Patterson & McFadden, 2009; Smith & Ferguson, 2005). Some studies have shown that this gap in course retention between the online and face-to-face environment may be even larger for mathematics and science, technology, engineering, and mathematics (STEM) courses (Jaggars & Xu, 2010; Wladis, Hachey, & Conway, 2012). Additionally, tentative evidence suggests that taking online courses early in the college career, such as at the community college level, may discourage students from returning in subsequent semesters or persisting in their degrees (Jaggars & Xu, 2011). Just as few studies have analyzed what happens inside community college mathematics classrooms as students and teachers engage with mathematical content, few studies have looked at what happens inside online mathematics classrooms. The few studies that have focused on online mathematics courses specifically include two journal articles, three dissertations, and one unpublished report (Ashby, Sadera, & McNary, 2011; Blackner, 2000; Bowen, et al., 2012; Smith & Ferguson, 2005; Summerlin, 2003; Zavarella, 2008) all but one are based on samples consisting of a few course sections and these studies assess only retention or grades of those who remained in the course, rather than exploring more direct questions of mathematical content, learning, and classroom interaction essential to the process of mathematical sense-making. This is where the expertise of mathematics education practitioners and researchers is needed to make more significant contributions.

The great potential of online learning at the community college is its ability to increase access, and therefore perhaps the progression and success of non-traditional students. It may be that the relative anonymity of the online environment in comparison to the face-to-face classroom may also change the dynamics of the community college mathematics classroom.

Although students online do know the names of other students and may be able to infer class, ethnicity, gender, and other characteristics from features such as writing style (see e.g., Thomson & Murachver, 2001), many other visual and interpersonal cues used when we respond in a face-to-face exchange are missing (or can be masked) in the typical asynchronous course environment. This more de-individuated environment may lead to differences in classroom interactions around mathematical content in ways that might benefit students. For example, while *stereotype threat* can negatively influence women's and some ethnic minorities' performance on mathematics tasks, the nature of the more de-individuated online environment may reduce this phenomenon.

Studies on computer-mediated communication suggest that the relative anonymity of the internet results in more equally distributed participation rates with an observed decrease in status-based influence in comparison to face-to-face groups (see e.g., Bordia, 1977; Dubrovsky, Kiesler, & Sethna, 1991). Lee (2009) and Lee and Nass (2012), working with videogames, showed that in computer-based environments in which the ethnicity or gender of other participants was less distinctively displayed, evidence of stereotype threat evoked by more competitive versions of the environment disappeared. Can we then anticipate that when the online environment masks the characteristics of students and when coursework is more cooperative, then typical patterns of lower performance and participation in community college mathematics classrooms, which are populated by students from traditionally underrepresented groups in mathematics (e.g. female, black, or Hispanic students) may improve or disappear altogether?

Furthermore, *numerical representation* (a mechanism suggesting that being a numerical minority in a group induces stereotype threat for the individuals in the minority) suggests that the higher number of female faculty and students at community colleges, coupled with higher proportions of female students in online courses in general and online STEM courses in particular (Wladis, Conway, & Hachey, n. d.; Wladis, Hachey, & Conway, n. d.-a, n. d.-b), may also alter the influence of stereotype threat in this context. A critical mass of women and minorities in these classes may reverse the impact of stereotype threat, for example, on the performance of female students on mathematics tasks (Ben-Zeev, Fein, & Inzlicht, 2005; Inzlicht & Ben-Zeev, 2000).

The potential for research questions focused on the community college online mathematics environment is large and diverse. We need to move beyond assessing student and instructor participation on asynchronous discussion boards by the *quantity* of instructor and student posts, or by some measure of threading, and when using the *quality* of posts, we need to attend to the mathematics being discussed, and not simply by the clarity of the writing, the presence of general higher-order thinking, or whether the posts include “educationally valuable talk” (e.g., Bliss & Lawrence, 2009; Kay, 2006; Meyer, 2003). Actual accounts of students’ or instructors’ engagement with authentic mathematical content during these discussions needs to be studied, and beyond that, we need to know how does mathematical sense-making tend to take place on these asynchronous online discussion boards? How does that differ from synchronous face-to-face mathematics discussions (in which most of the learning theories that we use now are based on), and how do these differences affect actual student understanding of mathematics? Making evident the overlap across our areas of research, but also keeping an eye on what matters most, we also need to ask, what kind of particular *mathematical knowledge for teaching* is necessary for creating effective asynchrouous online discussion board questions? What is the appropriate level of scaffolding for all students to be able to work on the question productively during times when they are waiting for an instructor response? What kind of instructor feedback (e.g. frequency, level of detail, level of personalization to individual students, attention to mathematical explanations) is the most effective in egagingengaging students to wrestle with and master particular higher-level mathematical concepts in an asynchronous environment? How do differences in how *stereotype threat* might play out in the online context affect the mathematical practices of students and teachers in online math courses in terms of the way in which certain definitions are operationalized or the level of abstraction used to explain or discuss mathematical concepts? W*ait-time* (Tobin, 1986, 1987) a key feature in face-to-face interactions needs to be re-conceptualized for the asynchronous online environment, where the time between a student question and an instructor response may be measured in days rather than seconds. We could also ask, how might this *wait-time* affect student willingness to engage in difficult mathematical problems or student understanding of particular mathematical concepts?

What Next?

At this moment, community college mathematics instructors, administrators, and policymakers are making decisions about how community college mathematics classes should be taught, how the community college mathematics curriculum should be structured, and how community college students should be encouraged to complete developmental mathematics coursework, credit-bearing mathematics classes, and college degrees. Yet, most of these decisions are being made in the absence of research-based evidence about how mathematics teaching and learning occurs in this setting. Without a concerted collaborative effort on the part of mathematics education researchers, practitioners, and policymakers, this situation is not likely to change.

The research agenda outlined in this article is the result of several years of discussion involving mathematics education and higher education researchers, community college mathematics faculty, policymakers, and administrators, several of whom fulfill more than one of these roles. Different from other initiatives in which researchers propose what needs to be done, this agenda has been developed jointly by researchers and faculty at community colleges. The working group participants have demonstrated over the last two and a half years that it is possible to conduct scholarly work in which practitioners, administrators, and researchers all have a voice, and that these three groups need not be distinct communities working separately or with adversarial aims. The dialogues that have emerged both from AMATYC's Research in Mathematics Education Committee and from the Research in Undergraduate Mathematics Education (RUME) working groups have been fruitful and energizing.

We believe that tackling these pressing issues requires approaches that are multipronged and multitiered, that call for multiple perspectives and methodologies, and above all that are based on collaboration between representatives of all these areas. Other initiatives (e.g., those spearheaded by the Carnegie Foundation for the Advancement of Teaching) have taken these approaches as well. We highlight that the work that we are proposing is centered on students' learning of authentic mathematics inside community college mathematics classrooms. This is fundamental to the work conducted under this proposed agenda.

Mathematics education researchers need to begin to concentrate more extensively on issues of mathematics learning in the community college context and collaborate with the practitioners who have expertise in the teaching and learning of mathematics in this setting. Not doing so could result in decision-making about teaching methods, curriculum, and policy in the absence of understanding how community college students learn authentic mathematics. We do not want the structure of community college mathematics education to be dictated by anecdotal evidence or by research that does not attend to instruction and learning of mathematics. We must then move forward with a research agenda on community college mathematics education in which larger numbers of mathematics education researchers and practitioners work together to address questions of teaching and learning in this context. Only through this kind of collaboration can we ultimately provide effective mathematics instruction to the roughly half of all United States undergraduates who take courses at community colleges; and improved mathematics instruction is essential if these students are to successfully complete mathematics courses and college degrees, and if they are to apply mathematical knowledge effectively in their careers, their lives, and their roles as citizens of a democratic society.

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Submitted March 7, 2013

Accepted September 16, 2013

Appendix: Participants in the 2011 and 2012 RUME Working Groups

2011 RUME Working Group Participants

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Elaine Lande, *University of Michigan*
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April Ström, *Scottsdale Community College*
Laura Watkins, *Glendale Community College*
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2012 RUME Working Group Participants

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Jim Gleason, *University of Alabama*
Kelly Mercer, *Portland Community College*
Vilma Mesa, *University of Michigan*
Beverly Meyers, *Jefferson College*
Ann Sitomer, *Portland Community College*
John Smith, *Pellissippi State Community College/The University of Tennessee*
Laura Watkins, *Glendale Community College*
Mark Yannotta, *Clackamas Community College*
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