Mathematics Education at U.S. Public Two-Year Colleges

Vilma Mesa[1]

University of Michigan, Ann Arbor

In this chapter I synthesize past and current research conducted at U.S. public two-year colleges and propose future directions for research in this context. The chapter is organized into four sections. In the first section I present a summary of the evolution of public two-year colleges, also known as community colleges, to provide a context for the work described here. The section includes a brief overview of the main characteristics of this particularly American postsecondary institution. The next two sections review mathematics education research conducted at two-year colleges between 1975 and 2004 and more recent work done since 2005. The final section is devoted to future directions for research in this context.

The U.S. Public Two-Year College

Before the turn of the 20th century, around 1893, the presidents of several Midwest and California universities—Henry Tappan (University of Michigan), William Folwell (University of Minnesota), William Harper and James Angell (University of Chicago), Starr Jordan (Stanford University), and Dean Lange (University of California)—advocated for the addition of two years to the existing four-year high school program and for the creation of a new institution, the *junior college,* that would teach the courses normally taught during the first two years of the university curriculum. The new high school courses were meant to better prepare those students who were interested in research and who would afterwards pursue a university degree and give the rest of the students an honorable and attractive path of postsecondary education at the junior college, a path that prepared them for work (Dougherty & Townsend, 2006; Labaree, 1997; Mirel, 2002).

[1] I thank the Teaching Mathematics in Community Colleges research group at the University of Michigan for feedback on earlier versions of this manuscript. The research reported in this article has been supported in part by the National Science Foundation through grants DRL-0745474 and DRL REESE #0910240. Opinions expressed here are the sole responsibility of the author and do not reflect the views of the Foundation.

As a result of this proposal, the National Educational Association appointed the Committee of Ten, a group of prominent academics led by Harvard's president, Charles Eliot, and charged them with establishing guidelines for a college preparatory curriculum for secondary schools that would be open to all students (National Educational Association, 1893). In 1893 the Committee of Ten (National Educational Association, 1893) recommended a full 12 years of public schooling, with the last four years as high school. Prior to this, schooling was neither universal or comprehensive as less than 10% of 14- to 17-year-olds were enrolled in high school (Mirel, 2002; National Council of Teachers of Mathematics, 1970; Tyack, 1974). Besides the college preparatory curriculum, the committee proposed a standard measure of credits for the new high school courses that would allow transferability to the universities and comparability across programs. By adding these two years to the high school program, the universities would be relieved from teaching elementary mathematics courses (e.g., algebra) and could concentrate on more advanced topics, such as trigonometry and calculus. Moreover, the creation of the junior college ensured that only students interested in research-oriented degrees would attend a university. This move served to increase the selectivity of the universities of the time. According to Labaree (1997), this arrangement of two more years in high school and the creation of the junior college "expanded educational opportunity while protecting the exchange value of the elite educational credentials and promoting the efficient allocation of students into the job structure" (p. 199).

In its early days, the junior college fulfilled two main academic functions: transfer to a four-year institution and general education. The inclusion of vocational or technical education to some extent eclipsed these academic functions (Thelin, 2004). Over time an increasing number of adults searching for more enriching opportunities in formal and geographically accessible settings meant that junior colleges were well positioned to satisfy a fourth demand—the community's leisure needs. The change from junior college to *community college* reflected the addition of this function. By the 1950s, community colleges offered the public an affordable option to go to college; the institutions were perceived as truly democratic, given their open access policies and the low cost of tuition. By the 1980s at least half of the U.S. freshman population was enrolled in a community college (Thelin, 2004). However, a decline in transfer enrollments in universities coupled with studies showing a decline in graduation rates of transfer students shed a negative light on community colleges (Brint & Karabel, 1989). A remediation function has slowly been imposed on the institutions, as one can infer from the dramatic change of the share of remediation in mathematics between two-year institutions and four-year institutions since 1995 (see Blair, Kirkman, & Maxwell, 2013; Loftsgaarden, Rung, & Watkins, 1997; Lutzer, Maxwell, & Rodi, 2002; Lutzer, Rodi, Kirkman, & Maxwell, 2007). Economic uncertainty in the 1990s that continued into the first decade of the 2000s added a sixth function, that of retraining workers laid off because of shrinking manufacturing in the United States and veterans returning from the various wars in the Middle East. By 2010, community colleges had come to fulfill six major functions: transfer, general education, vocational training, adult enrichment, remediation, and career retraining. These functions satisfy three foundational goals of the American educational system: (1) democratic equality (by providing more options for people to study via general, technical, and enrichment offerings and an open access policy); (2) social mobility (by facilitating transfer to a four-year institution); and (3) social efficiency (by making sure that people are prepared for the jobs that society needs, A. M. Cohen & Brawer, 2008; Dougherty, 2002; Labaree, 1997). No other institution of higher education has such a complex set of demands and such diversity of functions.

Simultaneously, the perception of community colleges in the literature has been negative. They have been unfairly labeled as "cooling-out" institutions (Clark, 1960, p. 569), "huge shopping malls" (Labaree, 1997, p. 207), and "high schools with ash trays" (Jennings, 1970, p. 16). They have high levels of attrition, low rates of degree completion and transfer, and a disproportionate investment in remedial education[1] relative to other higher education institutions. Such problems are specially heightened in mathematics. Some argue that their multiple functions and diverse goals, together with the vicissitudes of federal, state, and local funding are breeding grounds for such "failure" (Grubb, 1999; Jacobs, 2011; Labaree, 1997). Features of these institutions, specifically the characteristics of their students, the faculty[2], and the curriculum, help explain, or make less surprising, why such "failure" is more likely to happen in this setting relative to other institutions of higher education.

As of 2015, there were about 1,150 two-year colleges in the nation, enrolling close to seven million students, roughly 41% of all U.S. undergraduate students. In 2005, nearly 1.7 million students (48% of all the enrollments in undergraduate mathematics) took mathematics courses in public two-year colleges, an increase of 26% from the figure reported in 2000 (Lutzer et al., 2002; Lutzer et al., 2007). By 2010, 1.9 million students (46% of all enrollments in undergraduate mathematics) were taking a mathematics course at a two-year college (Blair et al., 2013). The students in these institutions are more likely than students in public four-year institutions to work 20 hours or more per week at the same time they are pursuing their degree (30% and 25% respectively, Snyder & Dillow, 2013). They also tend to be older: 67% of students 25 to 34 years old were enrolled at a two-year public institution. Two-year public colleges also have more women who are part-time students (59% of all two-year female enrollments) relative to four-year colleges (24% of all four-year female enrollment) and more students from ethnic minorities (44% of all two-year enrollment) than four-year colleges (34% of all four-year enrollment (Snyder & Dillow, 2013). These figures are a consequence of the open door policies of the two-year colleges, and they closely reflect the current fabric of the aspiring American middle class.

From 2000 to 2010, the number of full-time mathematics faculty in community colleges grew 34% (to nearly 9,500 faculty) and the number of part-time faculty grew 65% (to nearly 26,000 faculty), mirroring the increase in community college enrollments. Full-time mathematics faculty taught an average of 15 hours per week whereas 54% of part-time faculty taught six hours per week or more (Blair et al, 2013, p. 182). Moreover, 66% of the entire instructional faculty in mathematics was employed part-time, and they taught 44% of all two-year college mathematics sections, mostly the developmental mathematics courses. In contrast, at four-year institutions, 20% of sections of these courses were taught by part-time faculty.

In 1995, the number of students taking a remedial mathematics course at a four-year college or university was 222,000 (or 15% of their total enrollment); 15 years later, that number was 334,000 (11% of their total enrollment). The figures for two-year colleges were 799,000 in 1995 and 1,150,000 in 2010 roughly 57% of the total enrollment in mathematics at two-year colleges in both years. That is, by 2010, two-year colleges enrolled almost four times as many remedial mathematics students as other institutions of higher education (Blair et al., 2013; Lutzer et al., 2007). The percentage has been stable since 1990 but percentages mask the tremendous increase in actual numbers of people needing remediation.

A typical sequence of mathematics courses offered at two-year colleges, which has been in place since the inception of the junior colleges (American Mathematical Association of Two Year Colleges (AMATYC), 1999), is shown in Figure 37.1.

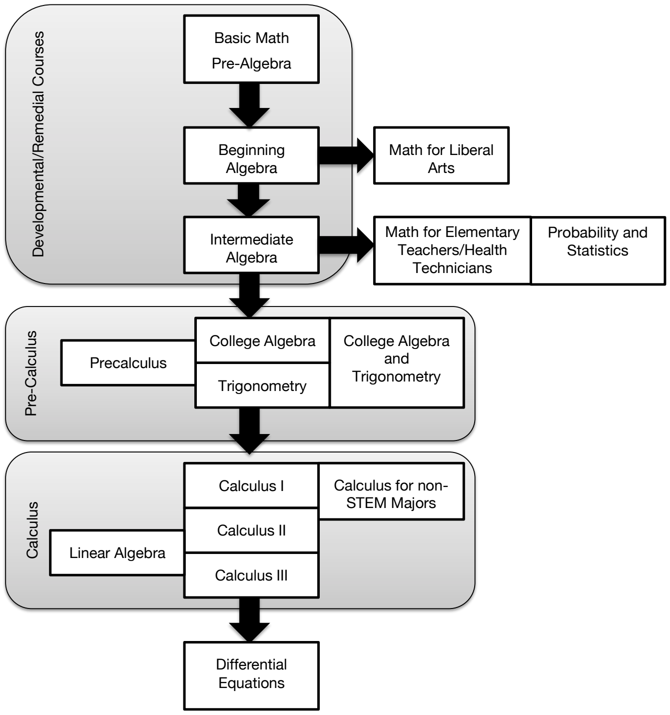

Figure 37.1: Typical sequence of mathematics courses offered at community colleges. Adapted from *Knowledge, attitudes, and instructional practices of Michigan community college math instructors: The search for a knowledge, attitudes, and practices gap in collegiate mathematics,* (Doctoral dissertation) by M. Andersen, 2011, Western Michigan University, Kalamazoo, MI, p. 14).

The courses in the developmental box cover content typically taught in the middle and high school curriculum. Proficiency in some of these courses allows students to transfer to other college-level courses according to students' majors (e.g., mathematics for liberal arts, probability). Out of the 1.9 million students taking mathematics in two-year colleges (Blair et al., 2013), approximately 61% enroll in a developmental course. Approximately 20% enroll in precalculus courses, as they plan to pursue a science, technology, engineering, mathematics, health, or business degree. The calculus and postcalculus-level courses are mostly intended for science, technology, engineering, and mathematics (STEM) majors. But at community colleges, only 7% of students enroll in these courses (Bragg, 2011).

Courses in the developmental box usually do not carry credit that counts toward a major or a degree. The proportion of students who begin a sequence of developmental courses and successfully complete a college-level course is very low nationally, only 25% (Bahr, 2007, p. 698), which represents an economic loss for the remaining 75% of students who intended to transfer to a four-year college or university but could not (Melguizo, Hagedorn, & Cypers, 2008). Taken together, these features contribute to negative perceptions of community colleges. This perception of failure is tied to an ideology suggesting that what matters is not that students are enrolled in the colleges (accountability via access—logic of access), but that they are obtaining a certification or a degree (accountability via student outcomes—logic of completion). This shift has made evident the need to attend to features of the student experience at community colleges that may contribute to their success.

In the following section I present a brief synthesis of the research on two-year or community colleges from 1970 to 2004, highlighting trends and main topics researched. In this period there were very few studies that specifically investigated mathematics education in postsecondary classrooms and even fewer that were located at two-year colleges. The selection of 1970 as the starting point is intentional: in 1975, the *Community College Journal of Research & Practice* was launched. This publication focuses on serving a growing community college audience and practitioners in particular, but it also targets researchers. There was scant published scholarship that targeted community colleges in the 5 years before it began. The selection of 2004 as the cut-off point for this section is also intentional: since 2005 there has been an explosion of attention to community colleges, fueled by the high cost of higher education and the economic recession; community colleges have increasingly been perceived as the only option that many students have to complete a college degree (Bailey & Morest, 2006).

Early Research on Community College Mathematics Education, 1970–2004

To obtain the studies I refer to in this section, I searched the educational databases ERIC and PyschInfo for journal articles whose abstracts contained any of the following key words: "mathematics," "junior college," "two-year college," "community colleges," or "adults." I limited this review to scholarship published in journals. Relevant dissertations, conference presentations, and preliminary research reports from research centers are included in the section on current research only because there were too few prior to 2005 I determined inclusion by further reading and chose only those articles that included adults or postsecondary students at two-year colleges. I divided the time span into decades, and for each time frame I noted the number of articles found and the number actually relevant for the review.

I identified 98 articles published in academic journals between 1970 and 2004 using the keywords noted, but only 40 actually studied populations drawn from two-year colleges; only about half of these articles included mathematics as a major feature of the analysis. Indeed, mathematics education was not a prominent feature of the research in this context prior to 2005. Table 37.1 shows the breakdown of the number of studies to give a sense of the trends that emerged in this era.

Table 37.1. Number of Journal Articles Dealing with Mathematics at Community Colleges Between 1970 and 2004

Time frame	number of articles identified	number of articles retained	number of articles dealing with mathematics
1970–1979	11	4	0
1980–1989	20	4	3
1990–1999	31	9	4
2000–2004	36	23	18
Total	98	40	25

Of the four articles published between 1970 and 1979, two concerned models to predict student performance in community college courses (Edwards, 1972; Weidenaar & Dodson, 1972), one studied how well transfer students performed in their transfer institution (Nickens, 1970), and the other surveyed students about their perceptions of their instructors' effectiveness and the association between this perception and instructors' training and experience (Potter, 1978). Although mentioned, mathematics played a minimal role in these studies: students' scores on mathematics tests or their grades in mathematics courses were used as one of several variables in the models, or the researchers included mathematics students in the sample.

The four articles retained from the 1980s that addressed mathematics dealt mainly with curriculum and pedagogical issues. Hector and Frandsen (1981) tested three methods to teach algorithms for computing with fractions and found that there was no advantage of any one over the others for their community college students. Sowell (1989) conducted a meta-analysis on the impact of manipulative use across different ages, from schoolchildren to adults, and found that an extended use of manipulatives was more important than whether students were exposed to them or not. Burton (1987) proposed a different curriculum to prepare minority students before they enroll in a teacher education program in Britain. In the other study that drew from community college populations, Bridgeman (1981) proposed using an analysis (utility of raw gain) to assess the validity of placement tests. Students' GPA gains over a semester were tracked and contrasted with their scores on placement tests; the analysis was used to calibrate the placement tests. Similar to the 1970s, mathematics played a minimal role in these studies; however across these, we see the emergence of the research questions that would drive community college scholarship for the next 20 years: efficacy of interventions, curriculum reorganization, and effectiveness of placement. Students' learning would mainly be operationalized via grades in courses or their performance in courses; likewise, classroom activity and disciplinary content would be cursorily addressed and would not play any significant role in the studies.

Of the nine articles identified in the 1990s, four addressed curricular issues in community colleges: ideas for new courses for women's studies programs that included activities drawn from ethnomathematics, programs that involved faculty at community colleges in delivering professional development for teachers in nearby K–12 schools, or perceptions of administrators and faculty at the colleges about the value of specific programs, such as technical preparation (Farrell, 1994; Forman, 1995; Lai, 1996; Prichard, 1995). All these studies dealt with mathematics. The remaining five studies provided descriptions of characteristics of students at community colleges, including mathematics performance, with emphasis on ethnicity, gender, or transfer (Bach, Banks, & Blanchard, 1999; Bohr, Pascarella, & Nora, 1994; Farrell, 1994; Kraemer, 1995; Pascarella, Bohr, Nora, & Terenzini, 1995). An important volume published in this decade, *Honored but Invisible*: *An Inside Look at Teaching in Community Colleges* (Grubb, 1999), provided an unprecedented analysis of instruction at these institutions that highlighted problematic practices: teaching was lecture-based and emphasized rote memorization and the curriculum was compartmentalized. In addition, in spite of being teaching institutions, the community colleges had very little support for instructional improvement and no collegial discussions about instructional aspects such as curriculum, assessment, learning, or teaching. Grubb, an economist who cared about vocational education, pointed to a major absence of scholarly work on instruction in the higher education community in general and the lack of research on community colleges in particular.

There were 23 articles published in the first half of the 2000s that dealt with community colleges or with adult education, but only 18 addressed mathematics. The most common topics were curriculum (8 articles) and instructional strategies (5 articles). Essays on the preparation of teachers (2 articles), investigations of students (1 article), placement (1 article), and instruction (1 article) constituted the remaining papers. Although the number of publications on community college mathematics education in this period increased, only 5 of the 18 articles were empirical.

Two of the eight articles dealing with curriculum investigated whether specific programs (an online platform for distance learning and a medical technical preparation program, respectively) were effective (Perez & Foshay, 2002; Shimony et al., 2002); three suggested content and course reorganizations: two to fit their clients' needs in engineering (Craft & Mack, 2001; Umeno, 2001) and the other to adapt to the changing knowledge-based society in Singapore (Low-Ee, 2001); one reported that mathematics was rated as not necessary for the safety program according to safety professionals (Adams, 2003); one proposed the infusion of ethnomathematics activities (Weiger, 2000); and the remaining one investigated the use of a syllabus for organizing student work (Baker, 2001). Only two of these articles on curriculum (Perez & Foshay, 2002; Shimony et al., 2002) reported empirical studies.

The five articles dealing with instructional support described activities that instructors could carry out in their classrooms to facilitate student learning. The supports ranged from web-based systems that gave students problems to practice (Katsutani, 2001; Yoshioka, Nishizawa, & Tsukamoto, 2001) to use of images and technology (Aso, 2001; Saeki, Ujiie, & Tsukihashi, 2001) and ways to modify a task so that it could be contextualized in teaching for different levels of understanding (Laughbaum, 2001). These articles were essentially descriptions of activities that were done in the classroom, written as essays, and did not include empirical data. The two articles related to K–12 teachers or teacher education discussed the importance of community colleges in teacher preparation, presenting guidelines from an effort to address this issue in Virginia (Wood, 2001) and various positions regarding administrative issues to consider in the preparation of future instructors at community colleges (Sophos, 2003).

The three remaining articles report empirical studies. Jones, Reichard, and Mokhtari (2003) sought to identify disciplinary differences in learning styles in men enrolled in mathematics, science, English, and social studies courses at a community college. Armstrong (2000) investigated the predictive validity of placement tests with students' grades in mathematics and English courses and found that although most of the variance was explained at the student level, adding instructors' grading increased the accuracy of the production. The last article focused on teaching (Waycaster, 2001). This article is exceptional in that the author, Pansy Waycaster, conducted a long-term observation of various developmental mathematics classes to document how instructors used dialogue and technologies such as demonstrations in their classes, correlating these uses with students' performance in subsequent mathematics courses. She found a positive correlation of these features with student performance.

As can be seen from this brief review, mathematics, its teaching, and its learning at community colleges were not studied in any significant way in this 35-year span. Institutional aspects (e.g., successful placement) and curriculum issues were more prominent, but the research fell short of offering suggestions that were tied to the work that faculty do when they teach. Most of the work was done at the institutional level, with measures that might not reflect students' learning. There was, however an increase over the years in studies attending to classroom issues, most notably in the 2000s, although empirical work remained very limited.

Fortunately this trend has changed significantly in the past 10 years as more high-quality research has emerged, primarily attending to students' performance in mathematics.

Current Research on Community College Mathematics Education, 2005–2014

In the past decade there has been an increased interest in issues of community college mathematics education. There has been research on low success rates in developmental mathematics courses (Attewell, Lavin, Domina, & Levey, 2006; Bahr, 2008, 2010; Bailey, 2009; Bos, Melguizo, Prather, & Kosiewicz, 2011; Calcagno & Long, 2008; Melguizo et al., 2008); specific aspects of instruction: faculty, students, and content inside the classroom (Leckrone, 2014; Mesa, 2010c, 2011; Mesa, Celis, & Lande, 2014; Mesa & Lande, 2014; Sitomer, 2014); and curriculum reform (Van Campen, Sowers, & Strother, 2013). This trend has been the result of several forces, the main being the shift from a logic of access (i.e., assessing the success of a college by the number of students who enroll) to a logic of completion (assessing the colleges by the number of students who obtain a degree or certification, see Baldwin, 2012) due to increased accountability pressures stemming from reductions in federal support for state education budgets and from political discourses that affirm that community colleges are an important vehicle for completing a college degree (The White House, 2010). Although some attention is better than no attention, as is clear from the research conducted after 2004, there is still more work to do to better define relevant constructs (e.g., success) and to increase basic research on students' and instructors' experiences inside community college mathematics classrooms.

The majority of the scholarship, however, continues to be conducted in the field of higher education (rather than mathematics education), where community colleges are seen as the primary (if not the last) institution well-positioned to advance agendas that promote equal access to higher education to all segments of the population (Bailey & Morest, 2006). Community colleges are seen as well positioned because of their open access policies, their low tuition, flexibility in course offerings, and proximity to communities with high proportion of under-represented students in higher education. In higher education scholarship, issues of student access, retention, and completion have been at the forefront and have largely determined the research agenda on community colleges—mathematics is ancillary, studied because mathematics courses are the main barrier to students' fulfillment of their academic goals. Failure in mathematics courses works against the advancement of equity goals that seek to diversify the STEM workforce by increasing the access of students who are traditionally underrepresented in those fields. Community colleges are well positioned to contribute to equity goals because they attract the profile of students that are needed in such fields (Bailey & Morest, 2006; Cullinane & Treisman, 2010). Thus, higher education scholarship attends primarily to features of institutional organization and economic returns for students. That research, although useful, bypasses instruction in the disciplines and falls short of suggesting actionable strategies that can be implemented in the classroom. This literature also suggests the addition of resources such as learning centers, advising, early warning systems, and monetary incentives for students who enroll, which is a deficit perception: the students lack something; if that something is provided, then things will be different. The problem, however, is too complex for strategies based only on addition of resources or on economic incentives to be sustainable (Quint, Jaggars, Byndloss, & Magazinnik, 2013). Other suggestions, such as curricular modifications (e.g., online courses, modularized content, or accelerated sequences) that deliver a quick fix to provide what students lack to enter a college-level mathematics sequence have also been studied, but without attending to features of implementation (Fong & Visher, 2013; Scrivener, Weiss, & Sommo, 2012; Twigg, 2012). The scholarship supporting the value of these curricular approaches—which are operating on a deficit view as well—is in its early stages, and some of it suffers from methodological limitations (e.g., small, nonrandom samples, inappropriate statistical techniques, or nonindependent evaluators). The value of these approaches is mostly in cost reduction for the colleges: fewer full-time faculty can oversee a larger number of paying students who are taking more modules over a shorter time period. Thus, economic rather than academic interests are driving these curricular reforms at the community college level. As of today, it is yet unclear that students benefit from these quick-fix approaches or which students benefit more from such curricular reorganizations, as on average there is no significant impact for students in grades or degree completion (Twigg, 2012). Within an era in which the logic of completion dominates the political discourse, institutions have few research-based options that can be used to address failure. Mathematics education researchers should not stand on the sidelines.

In what follows, I describe research conducted in the past 10 years that has started to make contributions to the scholarship on mathematics education at community colleges, going beyond economic issues and attending more closely to mathematics instruction. To identify relevant scholarship, I used the same strategy described for research before 2005 (searching two major educational databases for appropriate keywords), but I included reports, unpublished reports, and dissertations as a more important number of them were available in this period. I was able to find 98 documents. Of these, 81 addressed community colleges, and of these, 50 dealt with aspects of mathematics or mathematics in combination with another subject (e.g., English or the sciences). The other 31 articles, although relevant to community colleges, dealt with aspects that are more generic: impact of dual credit (e.g., Kim & Bragg, 2008), impact of age on degree-completion rates (e.g., Calcagno, Crosta, Bailey, & Jenkins, 2007), counseling and advising (e.g., Hlinka, 2013; Hugo, 2007), or prediction (e.g., Kingston & Anderson, 2013; Kowski, 2013; Wolfle & Williams, 2014). Because of their generic nature I did not include them in this summary.

Mesa, Wladis, & Watkins (2014), in arguing for a research agenda that addresses problems pertinent to community college mathematics education and that capitalizes on mathematics education knowledge, suggest a conceptualization of the agenda around instruction. Instruction, defined as the interactions among the teacher, the students, and the mathematical content embedded within a particular environment and changing over time (D. K. Cohen, Raudenbush, & Ball, 2003), provides a useful organizational framework to discuss current mathematics education scholarship at community colleges. For the purposes of this review, I organized the documents into four areas—students (15 documents), curriculum (17 documents), faculty (8 documents), and instruction (12 documents)—using the unit at which the claims are made (students, curriculum, faculty, and instruction) to make the categorization. The classification of some specific articles is somewhat capricious, as in several cases, the studies included claims that involved more than one of these categories. It is a useful, albeit rough classification that also highlights the absence of research in some areas (e.g., assessment). For each of the sections, I start by describing the scholarship I identified, highlighting specific contributions made. In the "Future Directions for Research" section below, I discuss what I see as promising trends as well as missed opportunities that can shape the future of research in this context.

Students

Two major categories of questions are addressed by the 15 documents in this category: student performance questions in studies conducted by higher education scholars (8 studies), and student learning questions in studies conducted mainly by mathematics education scholars (6 studies). The higher education studies use various measures to establish performance (e.g., GPA, number of courses passed or failed), retention (number of students re-enrolling at the college), persistence (number of students who stay in their programs), placement (number of students starting the mathematics sequence at different courses), and impact of remediation using large data sets ($n > 1{,}000$) mainly from institutional research offices (Bahr, 2013; Crisp & Delgado, 2014; Gonzalez, 2010; Hagedorn, Lester, & Cypers, 2010; Kingston & Anderson, 2013; Kowski, 2013, 2014; Lockwood, Hunt, Matlack, & Kelley, 2013). The main message from these studies is that remediation in mathematics is a major problem for community colleges. However, this information is hardly news to the mathematics education community: in 1995, for example, 63% of department chairs at two-year colleges surveyed by the Conference Board of the Mathematical Sciences classified remediation as a major problem for their departments (Loftsgaarden et al., 1997). The proportion of chairs classifying remediation as a major problem in the 2010 report was 67% (Blair et al., 2013). The higher education scholarship, however, is inconclusive regarding the effects of remediation; some studies indicate that it is detrimental (Bahr, 2013), whereas others suggest that it is efficacious (Kowski, 2014). None of these studies surveyed students about their personal views, motivations, or attitudes regarding mathematics, all of which can have an important influence on academic outcomes. These studies also ignore the precarious structural conditions under which community college students attend college, including full-time, low-wage jobs; family, financial, and health obligations; and unreliable transportation or family care. In assessing the success of remediation and student performance at community colleges, scholars tend to use the same parameters used with four-year institutions (degree completion, GPA, and time to degree) and the solutions are also similar to those proposed for four-year institutions: increase student support services, offer more advising, add personnel to the tutoring centers, offer transfer advice, make learning workshops mandatory, and so forth (Perin, 2004). These solutions, by assuming that the colleges just need to give the students what they are lacking so they can succeed, indirectly put the onus on the student to reverse outcomes that are mainly determined by conditions beyond the student's control, implicitly using a deficit view of the problem. These studies would more likely be valid if in their modeling they could account for the impact of key structural conditions.

The remaining seven documents about student learning address a range of topics, including specific content investigations, such as proportional reasoning (Sitomer, 2014) and arithmetic tasks (Givvin, Thompson, & Stigler, 2015, April; Stigler, Givvin, & Thompson, 2010; Trimble, 2015, April); more generic aspects, such as epistemological beliefs about mathematics learning (either as active, skeptical, or confident learners, Wheeler & Montgomery, 2009); achievement goal orientations (either towards mastery or towards performance, Mesa, 2012); and affective and academic perceptions, behaviors, resources, and benefits of being in a developmental course (Koch, Slate, & Moore, 2012). These studies attend closely to the students' experiences and views and acknowledge the complex set of relationships that contribute to their academic outcomes. I describe the six studies in more detail here.

Sitomer (2014) surveyed, interviewed, and followed adult students in a developmental class as they were learning proportional reasoning, explicitly countering a deficit view of the students. Her analysis of adult students' proportional reasoning strategies mirrors those documented in K–5 literature, although the adult students' strategies were always augmented by their everyday experiences. These experiences, she found, were unreliably helpful for them to solve proportional reasoning problems correctly. She documented that instructors rarely contextualized proportional reasoning problems, which appears to send the message to the students that contextualizing is not the "right" way to solve these problems. Over time, exposure to decontextualized problems led students to abandon their everyday experiences as a means of control for their work, effectively positioning their own knowledge as less valuable. In this particular case, exposure to instruction that does not acknowledge the role of personal experience in sense making translated into a loss for the students.

The studies by Givvin and colleagues (Givvin et al., 2015, April; Stigler et al., 2010) and Trimble (2015) used interviews and questionnaires to describe students' interpretations of answers to standard arithmetic tasks. They identified strong reliance on the application of memorized procedures and difficulties in explaining the meaning of some of the procedures. They also documented difficulties students had in controlling the correctness of their answers. These studies, stemming from a more psychological tradition, highlight the complex space that community college faculty and their students have to navigate given the accumulated experiences that have led students to enroll in remediation mathematics. Students bring knowledge and ways of learning that can, nonetheless, be detrimental to their academic advancement.

Wheeler and Montgomery (2009) were interested in investigating how community college mathematics students thought about the nature of mathematics learning. They used a Q-sorts technique in which 74 community college students sorted 36 mathematics specific statements related to beliefs of who they were as learners. The researchers identified three clusters of learners: active (not necessarily fond of mathematics, but willing to work hard to succeed at it), skeptical (had bad mathematical experiences and place the onus of success on having a good instructor), and confident (always been good at mathematics and had good experiences with it). Wheeler and Montgomery indicated that in all cases, students mentioned their instructors as instrumental for their success, thus showcasing the importance of understanding the role instructors have in creating positive learning experiences for students, particularly for those at community colleges.

Using an instrument to assess goal orientation (Midgley et al., 2000) tailored to the community college population, Mesa (2010) surveyed 777 mathematics students in courses prior to calculus and found they had a strong orientation toward mastery (understanding the material) rather than toward performance (obtaining a good grade), something that was not anticipated given the deficit literature on community college students. Moreover, interviews with 15 of the students' instructors revealed that the instructors underestimated the motivation, goal orientations, and expectations that their students brought to the mathematics classes. Instructors' perceptions revealed possible missed opportunities for them to capitalize on the positive goal orientations community college students bring to learning mathematics.

Finally, Koch and colleagues (2012) conducted a phenomenological analysis of interviews with three students in developmental courses in Texas to identify how they perceived the effects of taking developmental courses on their academic skills and the role of the courses in their academic goals. They found that students' affective perceptions evolved from being mostly negative at the beginning of the course to mostly positive after the developmental course was over. Similarly, students felt that their academic skills had increased as a result of taking the course. Regarding academic behaviors, after the developmental course students described being committed and more diligent than they had been before taking the course, expressing a strong willingness to persist, similar to what Mesa (2012) had identified. The students also described instructor behaviors that were useful (e.g., availability, making sure students understood the material) and institutional resources that supported their work (library, student centers, math labs, tutoring sessions).

Thus, in spite of the negative rhetoric surrounding remediation, it seems that at a personal level, community college students benefit from taking developmental mathematics courses. They are cognizant of the difficulties they face, and even if it is with perhaps too much optimism (after all, structural difficulties cannot be overcome by the individual alone), they bring a strong commitment to their work. These studies also suggest that instructors' work with students in the classroom is key for creating an environment in which students can engage with the mathematical content. It is less clear, however, how instructors are to accomplish this work.

Curriculum

As a topic with a long history in mathematics education, curriculum is an understudied area in community colleges. Although K–12 curriculum studies have evolved at a greater speed (Lloyd, Cai, & Tarr, this volume), very little of the existing theorization has trickled down into curriculum research at community colleges. The 17 reports on curriculum between 2005 and 2014 address three different areas: instructor use of curriculum (6 studies), programmatic changes (9 studies), and task analyses (2 studies). I discuss these next, using theoretical lenses developed in mathematics education, although in some cases the studies themselves used different theoretical perspectives.

Curriculum use. Remillard (2005) has noted that the literature contains different assumptions and theoretical positions about the relationship between teachers and the curriculum, following or subverting, drawing from, interpreting, or participating with it. Each of these reveals different stances the researchers take when describing how instructors interact with the materials they have available for teaching. The six studies that address instructors' use of curriculum at community colleges (Burn, 2006; Goldfien & Badway, 2014; Hirst, Bolduc, Liotta, & Packard, 2014; Jeppsen, 2011; Leckrone, 2014; Mesa, 2015) exemplify some of these assumptions. Burn's (2006) study about faculty reasoning regarding algebra reform describes how faculty's personal concerns for students, specifically providing a course that would serve them better than a course that has less applicability, were more important to them than heeding institutional calls for change. Simultaneously, Burn identified that the three departments in her study had different orientations toward what a reformed college algebra course should be. One department saw the course as a gateway to understanding and solving real-world problems emphasizing technology use, statistics, and multiple representations, whereas the other two departments sought to de-emphasize some content and change instructional and assessment practices to foster collaborative work and alternative ways for students to demonstrate their learning. The study did not investigate actual implementation, but the ways in which the faculty described their views of the algebra course suggest that their departments saw the faculty as either following or subverting the mandates to implement a reform of a critical course in the curriculum.

Jeppsen's (2011) and Leckrone's (2014) studies conceived of the instructors as agents in making decisions about use of curricular resources, although the instructors themselves tended to disregard the influence of the textbook on their teaching. Jeppsen's investigation of faculty decision making about using curricula for future mathematics teachers at four different community colleges showed that forces external to the instructors shaped the decisions regarding the use of those materials in their classrooms. Specifically, transfer policies, the textbooks chosen by the departments, and the administrative organization that supported the courses for elementary teachers were more powerful than the instructors' professional judgment about the curriculum and tasks that could be used. Similarly, Leckrone's study of calculus instructors suggested that they may be unaware of the many ways in which textbooks organize the instructors' teaching. Leckrone's observations of teaching and her analysis of the interview data revealed more instructor reliance on textbooks than what is explicitly acknowledged. Both these studies recognized the partnership that was implicitly enacted between teachers and curriculum, with instructors at times drawing from the curriculum and at other times interpreting it, even when they themselves were reluctant to recognize the partnership.

Goldfien and Badway (2014) investigated the challenges and affordances of the implementation of a bridge program that sought to contextualize the curriculum in biotechnology using various disciplines. They candidly described the difficulties of carrying out curriculum development and implementation with limited knowledge about these processes. They documented the learning that occurred at all levels of the implementation, illustrating the ways in which the community of faculty participated in the collective process of creating and enacting the curriculum change process at the institutional and departmental level. Likewise, Hirst et al. (2014) documented the way in which faculty and students benefitted from a collaborative research experience between community college and university research faculty that sought to increase community college students' participation in research. Ostensibly a program geared to increase students' transfer to a four-year institution, the project indirectly enhanced community college faculty's research capacity for supporting their students' development of research skills. Originally conceived as a university project, it evolved so that the community college counterparts became cocreators of the curriculum used in the research experiences.

Finally, Mesa (2015) discussed the way in which three different ways of enacting the mathematics curriculum at different community college courses can be seen as a participation in instruction, describing the curriculum as the "lived experience" that students and instructors co-create in classrooms with the mathematical content. In this essay, Mesa elaborates on Kilpatrick's (1999, August) position that curriculum and curriculum change need to be understood as the result of historical, political, and cultural forces rather than an act of an individual instructor or department.

Programmatic changes. Nine studies under this category describe modifications made to courses or course sequences either to accelerate students' progress through prerequisite mathematics (Asera, 2011; Cullinane & Treisman, 2010; Hern, 2012; Kalamkarian, Raufman, & Edgecombe, 2015; Merseth, 2011; Strother & Sowers, 2014; Yamada, 2014; Yizze & Reyes-Gastelum, 2006) or to facilitate adult students' adaptation to the college curriculum (Strucker, 2013). These studies are descriptive in nature, meant to inform institutions interested in pursuing similar work. Noteworthy because of their scope are studies of the impact of the Quantway and Statway course sequences (Strother & Sowers, 2014; Yamada, 2014), developed by the Carnegie Foundation for the Advancement of Teaching . These two sequences reorganized the content so that after one year, students earn credit for a college-level mathematics course requirement. Quantway focuses on quantitative reasoning and Statway on statistical reasoning. These sequences are designed for students who place two or more levels below college-level mathematics. Preliminary reports consistently showed around 50% successful completion of the year-long courses across the colleges in which the sequences have been implemented (Van Campen et al., 2013), an impressive proportion given that at participating colleges the average of combined pass rates for the courses leading to a college level course within one year is under 10% (p. 17). In terms of learning, Strother and Sowers (2014) showed that pathway students ages 18–24 perform higher than a comparable control sample (although significance is not reported), whereas Yamada (2014) reported that, relative to matched samples from the colleges, students taking the Statway sequence triple their success rates, with the larger pass rates for those students at two or three levels below college level courses. The pathways initiative is also noteworthy because the implementation of the curricula requires attention to challenges at the classroom, institutional, and system levels: for example, aligning learning goals with career opportunities (classroom level), guiding students through placement and program of studies (institutional level), and smoothing transitions between high school and community colleges and between community colleges and four-year institutions (system level). The promise of this work lies in the attention to the multiple systems that interact within this particular context, the involvement of faculty, and the attention to content.

Task analyses. The two task analysis studies were focused on college algebra textbooks (Mesa, Suh, Blake, & Whittemore, 2013) and on calculus I homework and exams (White & Mesa, 2014). In the first study, Mesa et al. (2013) investigated the quality of nearly 500 examples in college algebra textbooks used at community colleges and at their respective transfer institutions (Mesa et al., 2013). The study revealed, unsurprisingly, that the majority of examples in these textbooks ask students to perform procedures without connections, reinforce the use of symbolic over graphic representations (even in the chapter devoted to graphing), mostly require single numeric answers without explanations, and rarely require students to justify why their answers are correct. As has been highlighted in other studies of postsecondary mathematics textbooks (e.g., Lithner, 2004; Mesa, 2010a; Mesa, 2010b; Raman, 2004), such examples can be detrimental to the students who use textbooks as a resource for learning, because the students tend to follow the examples in the textbooks to learn the material (Weinberg & Wiesner, 2011). This approach of studying textbooks attends to the potential of the textbook to generate learning opportunities, but it does not account for what the faculty actually assigns to students. White and Mesa's (2014) analysis of tasks in worksheets, homework, and exams accounted for this. They analyzed the cognitive orientation of nearly 5,000 tasks assigned by five instructors from a single two-year college selected as a case study in the National Study of Calculus I (Bressoud, Rasmussen, Carlson, Mesa, & Pearson, 2010). The cognitive orientation of tasks had three major categories, *simple procedures, complex procedures,* and *rich tasks.* These definitions were adapted from various frameworks to fit the work that is done in calculus. Simple tasks require students to recollect information from memory or apply a one-step procedure. Complex procedure tasks require students to recognize what procedures to apply in a given situation or for them to use more than one nontrivial step. Conceptual knowledge plays a plausible role in this process. Rich tasks require students to make interpretations and inferences, apply conceptual understanding in addition to procedural fluency, critically analyze a mathematical claim, or create new examples or counterexamples. The analysis revealed that over half the problems instructors assigned for homework (from their common textbook) or during classwork were simple procedures (54%). However, in exams, instructors included proportionally more rich tasks (49%) than in bookwork (25%) or worksheets (37%). The literature suggests that K–12 teachers are more likely to use what is available in their textbooks when they teach (Valverde, Bianchi, Wolfe, Schmidt, & Houang, 2002). Yet this analysis suggests faculty can make an important difference in generating learning opportunities for their students that can overcome textbooks that have a disproportionate number of tasks with low cognitive demand. Further work on how faculty use their textbooks for designing instruction is clearly needed.

Faculty

The eight articles grouped in this category include surveys of instructional strategies faculty use or do not use in their classrooms (two articles) and exhortations or admonitions directed at faculty to use or refrain from using those strategies (five articles), which suggests a deficit perspective on the work of faculty, in addition to the deficit perspective on students seen in studies examined earlier. The exhortation and admonition articles do not report empirical studies. One additional article refers to faculty development.

Using a sizable sample of community college mathematics faculty in Michigan (~1,000), Andersen (2011) identified a gap between faculty knowing about a strategy and successfully (or willingly) using it in the classroom. She suggested that the likelihood of faculty using a strategy is related to their beliefs about teaching, learning, and mathematics rather than to their knowledge about a strategy. Moriarty (2007) identified barriers that science, technology, engineering, and mathematics faculty at three community colleges experienced when attempting to use inclusive pedagogy with diverse students, including those with disabilities: lack of an inclusive mindset, lack of knowledge about pedagogy, high teaching loads, and lack of time for instructional development. Similarly to Grubb's (1999) work on instruction at community colleges, these two studies point to the need to build community college mathematics faculty's capacity for acting within the structural challenges regarding teaching loads, class sizes, and time that community college faculty experience.

The articles exhorting faculty to use instructional strategies include three discussing the benefits of dialogue and classroom discussion to promote student understanding (Galbraith & Jones, 2006; Gordon & Gordon, 2006; Marshall & Reidel, 2005) and one advocating the use of technology to let students learn material at their own pace (Mills, 2010). A final article of this type suggested that instructors need to be cautious about abandoning the lecture (Wynegar and Fenster (2009). This suggestion was based on Wynegar and Fenster's conclusion that students in a lecture-based class had higher GPAs and lower attrition than students in a computer-aided class.

In spite of the large number of adjunct faculty hired by two-year colleges mathematics departments nationwide (68% of all two-year instructional faculty compared to 21% for four-year colleges, Blair et al., 2013), only one article dealt explicitly with part-time faculty. Gerhard and Burn (2014) investigated strategies that involved part-time faculty in college initiatives seeking to reform teaching practices. Like the students they teach, part-time faculty commute to campus, and they are more likely to be assigned to teach developmental courses than full-time faculty (Blair et al., 2013). Gerhard and Burn used several strategies meant to increase part-time faculty engagement with instructional reform at their campus. The strategies included incentives, reorganizing course prerequisites, providing instructional support, and giving targeted professional development in the form of a training program. A key finding from their study was that the training program alone was insufficient. Instead, the combination of the various strategies resulted in better engagement of the part-time faculty. In particular, the intentional relationship-building part of their program was the most effective feature that supported and ensured reform implementation. Thus, Gerhard and Burn suggest, any faculty development program that seeks to promote reform needs to acknowledge the shared responsibility between stakeholders in the colleges—the part-time faculty, the departments, and the institution—and be supportive of maintaining professional relationships over time.

As a whole, and with very few exceptions, the research portrays faculty as professionals lacking something: knowledge, will, time, or connections to their institutions, and suggests that they will need some form of support to modify their practice. Yet there is little research that investigates models to accomplish such tasks and almost no theorization that supports those models.

Instruction

Instruction in community colleges has not been systematically studied in the literature. An analysis of the articles that used the words "instruction" or "mathematics teaching" at two-year colleges revealed that the words were operationalized differently in different articles: mathematics instruction corresponded to the courses students took (which mostly aligns with the notion of curriculum), the grades that students received in those courses (more notably their GPA), or the resources or pedagogies instructors used in the classroom (e.g., technology, group work). The interactions among the instructor, the students, and the content, which happen inside the classroom, have not been examined (Mesa, 2007).

The majority of the articles discussed in this section are products of a research project that specifically investigated mathematics instruction at community colleges (Mesa, 2008). The project researchers sought to describe instruction in precalculus mathematics courses that prepare students for a STEM major (college algebra, trigonometry, and precalculus; see Figure 37.1) and to understand the reasons why community college faculty make instructional decisions that avoid strategies to facilitate student understanding in their classrooms. Here I briefly describe 12 documents that report the major findings from this program of research and one stemming from the National Study on Calculus I (Bressoud et al., 2010), which had a component about calculus instruction at two-year colleges.

What does community college mathematics instruction look like? A striking feature of the instruction that Mesa and colleagues observed at community colleges has been the amount of interaction between students and instructors in any given classroom, compared to mathematics classrooms in other postsecondary institutions (Mesa & Chang, 2010; Mesa & Griffiths, 2012). Although clearly dominated by the instructors, the lectures observed in these studies had a continuous stream of questions and answers posed by both students and instructors, a form of interaction that has been termed "interactive lecture" (Burn, Mesa, & White, 2015). Although the dominant form of interaction between students and instructors was what is known as the three-turn initiation, response, and evaluation/feedback (IRE/F) pattern, the frequency of these exchanges was so high that the process resembled a Socratic exchange. Faculty saw these interactions as a natural part of the learning process and felt strongly that their community college students needed to work out their questions *during the lesson* so they could be ready to work on the material once they left the classroom (Mesa, 2011). Simultaneously, the questions and answers focused on procedural aspects of the material. Although there were a nonnegligible number of questions that were of high-cognitive demand, in many cases, the instructors themselves answered those questions (Mesa, 2010c; Mesa & Lande, 2014). The instructors justified this practice in two ways. First, they perceived their students as having low self-confidence in their ability to do mathematics. Thus, instructors proposed questions they knew were within students' reach and ability to solve. As students answered these questions, the instructors reasoned, they would increase the feeling that they could participate in the mathematical community. Posing questions that were harder would deter students from participation. In addition, instructors saw their role as modelers of thinking. By answering their own harder questions, instructors were demonstrating their thought process so students could then repeat it on their own. They saw the need to provide models for students to build their own repertoire.

Another possibly unsurprising feature of mathematics instruction at community colleges is the variation in implementation of the interactive lecture across faculty and the lack of correlation between those implementations and the complexity of questions that instructors used. Mesa, Celis, et al. (2014) asked faculty about their approaches to teaching and observed them teach. They classified the instructors in three ways: (1) by how instructors described their approaches during interviews, (2) by the approaches the researchers documented being used in the classroom when the instructor was not dealing with mathematical content, and (3) by the complexity of mathematical questions instructors posed. On a continuum of practices from student-centered to content-centered, these researchers found a high correlation between the teaching approaches faculty described in the interviews and what they did in the classroom with nonmathematical content. In contrast, they found no correlation between those described approaches and mathematical question complexity. In other words, faculty espousing and using student-centered instruction were equally as likely to use complex questions as faculty not espousing or using such approaches. The analysis of classroom observation data from the national study of calculus I also corroborates the presence of a content-centered approach to teaching: instructors presented the material mainly through examples chosen to illustrate the content; the examples used tended to emphasize mastery of skills and procedural fluency with symbolic representations; and students participated mostly by asking questions or answering questions posed by the instructors (Mesa, White, & Sobek, 2015, November). Such patterns of interaction are remarkably similar to those observed in the analysis of trigonometry lessons at community colleges although a few differences were evident. In the trigonometry lessons, students asked or answered fewer questions than in lower-level courses, and graphing calculators were available and heavily used by students all the time. Three additional norms of teaching with examples in the trigonometry lessons were observed: (1) instructors rarely asked questions regarding the plausibility or correctness of a response or final solution to a problem, (2) instructors engaged the students by asking questions about how to apply known procedures rather than asking them to decide what procedure to apply, (3) and instructors offered as examples problems that contained all the information needed to solve them in only one way (Mesa & Herbst, 2011),.

These accounts of actual instruction of mathematical content, together with the findings regarding faculty knowledge of pedagogical strategies that foster student understanding lead to questions regarding the rationale for teaching decisions. Some work has been done in this area with community college settings.

Why does community college mathematics instruction look like this? In other words, what reasons do faculty have to justify this type of instruction? A first attempt at answering this question in the community college setting used a conceptualization of the work of the instructor not simply as a consequence of the individuals' will, knowledge, or interest, but as bounded by the various professional obligations to which instructors respond (Herbst, Nachlieli, & Chazan, 2011). Using animations of community college trigonometry classrooms whose norms have been breached (Mesa & Herbst, 2011), Mesa and Celis (2012, April) and Lande (2014) identified the professional obligations to which community college instructors responded as they discussed specific moments that called for an instructional decision. This research showed that faculty mainly justified their decisions through their obligation to meet students' learning, cognitive, and emotional needs in their classrooms. For example, faculty indicated a preference for problems that have one solution because they illustrate procedures more clearly, eliminating possible confusion. Instructors avoided sending a student to the board to show a solution because they were concerned that the student's already low self-esteem would be further negatively affected. Instructors' avoidance of other practices was also related to their obligations to the class as a whole, the discipline, or the institution. For example, allowing students to lead the discussion of alternative solutions to a problem would confuse the class (related to an interpersonal obligation), would likely include incorrect use of terminology (related to a disciplinary obligation), and would take excessive time that would alter the need to cover all the required content (related to an institutional obligation). It may not be surprising that community college instructors mostly justify their decisions through obligations to students as individual learners because part of what draws faculty to teach at community colleges is that teaching is central. It is possible to speculate that in other types of institutions, such as those that are research-oriented, instructors might be more inclined to justify their classroom decisions on disciplinary grounds. This is an empirical question that would need further study.

In addition to these findings, Lande (2014) contrasted the obligations to which full-time and part-time faculty responded and found no difference between the two groups. Thus, in terms of what faculty said they did in the classroom and why, the two groups were indistinguishable. More interestingly, Lande found that part-time faculty more frequently used tentative and hedging language, whereas full-time faculty used language that was more assertive and monoglossic, that is, less open to dialog and discussion (Lande & Mesa, in press). Lande argued that this can be explained by part-time faculty's weak connections to the colleges where they teach. The language choices the faculty made revealed their sense of diminished agency within their professional community. These studies confirmed that instructors respond to professional obligations that justify their behaviors in the classroom in ways that may make changing instructional practices more difficult. More work is needed to understand how these expressions of professional obligations can be altered by targeted faculty development, especially in light of findings regarding the positive impact of instruction that engages students in discussions of the material with the instructors providing opportunities for discovery learning (Freeman et al., 2014).

Future Directions for Research on Community College Mathematics Education

Although there has been an increase in scholarship on aspects of mathematics education at community colleges in the last decade, it is in its infancy. Relative to their higher education counterparts, mathematics education researchers, who have expertise in teaching, learning, and curriculum processes in mathematics, are neither raising nor answering questions that matter to community college practitioners. Higher education scholarship has defined the current research agenda on community colleges around student "success," which has been insufficiently defined as students' passing courses and attaining a college degree. This approach is unlikely to alter the status quo at the ground level, at the level that matters to the mathematics students and their instructors.

Mesa and colleagues (Mesa, Wladis, et al., 2014; Sitomer et al., 2012) have argued that mathematics educators need to reclaim a research agenda for community college mathematics that first and foremost attends to the everyday work of instructors with mathematics and with students in these classrooms, that considers the local conditions—structural and political—that shape mathematics teaching at community colleges. Moreover, they have argued for a redefinition of student success. Student success must account not only for progress toward fulfilling academic goals (e.g., transferring to a four-year institution, obtaining a certificate, changing careers) but also for mathematics learning. The research agenda, generated with input from various constituencies (practicing community college faculty, community college faculty pursuing doctoral degrees in higher education or in mathematics education, researchers in higher education, and researchers in mathematics education), proposes research in four major areas: instruction, students, curriculum, and e-learning. Core questions within each area are specific to the conditions that shape the work of students and instructors within this environment, with the ultimate goal of contributing to student success.

The scholarship reviewed in this chapter shares, for the most part, five features: (1) it assumes a deficit view of the various objects of investigation: students, instructors, and curriculum; (2) it devotes only superficial attention to mathematics and specific aspects of learning the content; (3) it uses the scholarship from K–12 and university settings as the guide for assessing work in the community college context; (4) it does not take up questions that matter to practitioners; and last but not least, (5) it lacks theoretical support. Future research on community college mathematics education needs to address these deficiencies.

There is both richness and great challenge at the core of work with community colleges. Continuing a deficit view will only perpetuate the image of impossibility that plagues work in this area. Researchers need to accept that the diversity of the community college setting can be its best asset for testing the robustness of their constructs; such context can truly expand their understanding of mathematics teaching and learning. Paying closer attention to how mathematics is dealt with when teaching it to adults who have had prior experiences with the material is a new task for mathematics education researchers. Research in community college mathematics education needs to capitalize on community college students' prior knowledge so that researchers can help instructors reorganize instruction so it is honest with respect to both the students' knowledge and the mathematics at stake. The studies reviewed here suggest that there is more work to do to accomplish this goal. Researchers need to be informed by findings from K–12 and university settings, but they need to be conscious that there will more than likely be a need to reinterpret and redefine constructs to fit the community college context. Unlike K–12 schools or universities, community colleges are teaching institutions fulfilling multiple missions, one of which, although not the most important one, happens to be to prepare students for a college degree. Keeping in mind these multiple goals allows researchers to put in perspective the perceived "failure" of mathematics education in community colleges. Involving faculty in defining the research questions must be a priority for further research (Wladis & Mesa, 2015). Researchers conducting work on community college issues need to involve community college faculty, because faculty are in a position to formulate questions that matter and to understand the context in which they work. Finally, theorization is an important area that is sorely lacking. Community college mathematics education rests in an odd space. It draws from research in mathematics education and its theories of learning and curriculum and its views about the preparation and development of teachers. But it also draws from research in higher education and its theories of institutional organization and curriculum and its views about faculty development. So far, there is little work to bridge these traditions, with the sad consequence of generating mostly undertheorized empirical work.

Besides addressing these problematic features, and beyond addressing the four areas proposed by the research agenda (Mesa, Wladis, et al., 2014), research in community college mathematics education must address student assessment and faculty development. The lack of theorization and empirical work in these two areas contributes to the acceptance of a definition of success that consists of merely passing mathematics courses. Success that does not account for learning is a weak proxy for the health of a mathematics education system. Likewise, the lack of investigation that supports the work of faculty in this setting poses a serious threat to community colleges' aim of being a space for democratic equality and social mobility.

The mathematics education research community has the capacity to advance understanding and to give depth to some of the initial answers to questions that matter in this context. The research community has the opportunity to work together with practitioners in pursuing research that can ensure a brighter future for students who enroll in community colleges as part of their academic pursuits. Concerted effort, with systematic investigations in the areas outlined here, can lead the research community further and faster to the construction of a robust knowledge base that will inform decision-making, empower faculty, and provide students with adequate resources for success. Such an approach will ensure that community colleges continue to play a significant role in supporting educational equity in our nation.

Notes

1. The bulk of remedial coursework takes place at community colleges. The terms "remedial," "developmental," and "pre-college" are used in the literature to refer to courses that cover K–12 mandated content: arithmetic, algebra, and geometry. These courses do not carry college credit. The Conference Board of the Mathematical Sciences (CBMS) uses the term "pre-college." Most of the literature in higher education and in policy documents uses the term "remedial." The American Mathematical Association of Two-Year Colleges (AMATYC)

uses the term "developmental." In this chapter these terms are used interchangeably, retaining the term used by the authors when describing their work.

2. Throughout this chapter I use the word "faculty" to refer to people working in mathematics departments in postsecondary institutions. I use the terms "instructor" and "teacher" to refer to people teaching postsecondary courses or in K–12 settings respectively. "Instructor" and "faculty" are used interchangeably. Likewise, I use the expression "faculty development" to refer to "professional development" as the former is the preferred term in the postsecondary literature.

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