Researching Mathematics Instruction in Community Colleges

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Abstract

A review of the literature of mathematics instruction and its relation to students' success in community colleges reveals definitions of instruction (as curriculum, as assessment, and as instructional practices) that are at odds with current research on mathematics teaching and definitions of success that might not fit the goals of the colleges. The literature highlights characteristics of students, instructors, and institutions that might be related to success but fails to look closely at the actual work that teachers do in their classrooms with their students and with the mathematics they teach. The lack of articulation of the notion of mathematics instruction limits our possibilities for developing a robust knowledge base that will move the field forward and that will support instructors as they teach in this setting and makes it more difficult to understand the relationship between students' success and instruction in community colleges.

Obtaining a higher-education degree brings benefits to the society at large in terms of income, health, and civic behavior (Baum & Ma, 2007). The rising costs of higher education and the changing economic outlook have made the community college a natural, and in many cases, the only, option for completing post-secondary studies (Dowd et al., 2006): near half of the undergraduate population in the United States is enrolled in a two-year college (Baum & Ma, 2007; Blair, 2006; Dowd et al., 2006; Lutzer *et al.*, 2007). Completion and transfer rates, however, for students in public two-year colleges are low (22% and 18% respectively, nationally, Dowd et al., 2006; Knapp *et al.*, 2006), which creates pressures on the administration and faculty to increase the number of students who complete their studies. Because mathematics is an almost universal requirement for all students in community colleges (Lutzer et al., 2007), math departments have to spend a considerable amount of resources in preparing the large number of students who are not ready to take on college work. In this sense, mathematics and English departments are similar; however, for mathematics the problem is compounded because students bring higher levels of anxiety towards the subject, a consequence of repeated prior failures with the material (House, 1995). In this context, it appears that mathematics instruction plays a significant role in preparing these students to succeed in their goals of achieving a higher education degree. This paper reports a review of literature that spans research in higher education and in K-12 mathematics education that seeks to answer the question:

> What does the literature say about the relationship between community colleges mathematics instruction and students' success?

I use the term instruction to mean the *shared work* on authentic mathematical content between *instructors* and *students* within *environments* (Cohen *et al.*, 2003). In Figure 1 these elements (instructors, students, mathematics, environments) are depicted, and the arrows are meant to represent the interactions that occur among them. The inner circle corresponds to the classroom, the larger circle to the school or the community in which the classroom is embedded.

The figure also highlights that students can interact among themselves, thus acknowledging that they can be 'instructors' to other students too.

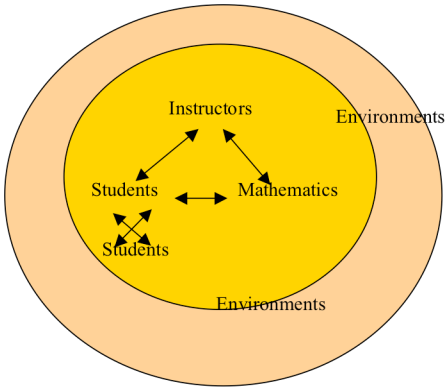

Figure 1: Instruction as interaction. Adapted from Cohen *et al.* (2003, p. 124)

In the model, the arrows between Instructors and Students and Mathematics (the instructional triangle) correspond to the work that teachers organize in order to engage students in learning. Ball and H. Bass (2003) have suggested that such work demands teachers to be able to:

- "Design mathematically accurate explanations that are comprehensible and useful for students;
- Use mathematically appropriate and comprehensible definitions;
- Represent ideas carefully, mapping between a physical or graphical model, the symbolic notation and the operation or process;
- Interpret and make mathematical and pedagogical judgments about (predictable and unusual) students' questions, solutions, problems, and insights;
- Make judgments about the mathematical quality of instructional materials and modify as necessary;
- Be able to pose good mathematical questions and problems that are productive for students' learning; and
- Assess students' mathematics learning and take next steps." (p. 4).

There is no reason to believe that instructors in community colleges, or in any other undergraduate setting, do not face dilemmas related to these activities as they prepare to teach. It is reasonable to think, however, that being in the environment of a community college requires instructors to make different decisions than if they were teaching in other settings such as a research institution or a private selective two-year college.

Student success, on the other hand, is an umbrella term used to account for positive outcomes in a number of different variables measured at the student level, for example, enrolling and staying in a program, obtaining a high GPA, passing courses, earning college credits, completing a degree, or transferring to a four-year college.

The review upon which this paper is based draws from 59 studies and reviews of the literature that provide valuable information for understanding the state of mathematical instruction in community colleges and its relation to success. The studies successfully describe the characteristics of students, instructors, and institutions, as well as the prevalence of certain instructional practices (e.g., lecturing). The literature consistently demonstrates the value of developmental (or remedial education) and the comparable quality of instruction between part- and full-time instructors. However, the literature is lacking from a coherent definition of instruction and a better conceptualization of success, as I describe next.

Mathematics Instruction and Success: Underdeveloped Notions in the Literature

I discuss here two insights I gained by reviewing the literature. The first regards the different meanings given to *instruction* in these studies. The lack of a coherent definition makes it difficult to compare and build upon studies to further our understanding of what it means to teach in this setting. Second, there were different meanings given to success, most of them derived from the research with selective institutions, that might not apply to community colleges.

Meanings of Instruction

There were three dominant meanings of instruction across the studies in this review: instruction-as-curriculum, instruction-as-assessment, and instruction-as-a-collection-of-instructional-practices.

Instruction-as-curriculum is perhaps the most common of the meanings given to instruction.[1] Under this meaning, "instruction" corresponds to *the object* instructors would teach, that is, the skills (soft, metacognitive, study), the class (developmental courses, algebra) or the content: teaching is that what instructors teach. Seeing instruction as the curriculum leaves out crucial questions regarding the actual work of instructors with that 'curriculum' and assumes that the curriculum will be implemented similarly across instructors. A number of studies in K-12 education have documented problems with this approach to instruction (Burstein, 1993; Cohen, 1990; Stodolsky, 1989; Travers & Westbury, 1989) and illustrated the crucial role that instructors play in delivering curriculum.

Instruction-as-assessment corresponds to the practice of taking the grades students obtain in their mathematics classes or in their studies to represent success under different modes of instruction (e.g., remedial, computerized). In this conception of instruction, the burden of the proof that something has been done is on the students, rather than on the instructors, with instruments that are presumed to be valid and reliable (exams, homework, quizzes). What instructors did to make sure that students obtained a given grade is left unexamined; as before, this view assumes that instruction does not matter as long as it is 'delivered' and that assessment practices are uniformly distributed and unbiased across instructors. The appropriateness of this practice has been contested in the K-12 education literature (Moss, 2004; Pellegrino et al., 2001; Wilson, 2004).

[1] Such shift is not new. Early discussions of instruction in the literature also defined it as the 'course of studies' or the curriculum that was imparted in mathematics departments (Mesa, 2006). See for example Cajori's (1890) *The teaching and history of mathematics in the United States*.

Instruction-as-a-collection of instructional practices (writing assignments, group projects, use of technology) seems closer to what instructors might actually do in their classrooms. Judging from the few studies available, lecturing can encompass different levels of student participation and introducing graphing calculators might change the classroom interaction. The scarcity of studies in this category implies that even using this approach to define instruction, we do not know much about what instructors actually do with each of those practices: how do they make decisions during planning, how they organize resources to accomplish their different goals, or how they assess what students learned. The lack of these descriptions of the actual work of the instructor in the studies generates information that is not that useful to accumulate knowledge and therefore does not help us in advancing our thinking about teaching in this setting.

Meaning of Success

The review revealed also that 'student success' in this setting is still being conceived in the same terms as in selective institutions, particularly those of four-year research institutions (where most of the research has been conducted). High drop out and low transfer rates are considered illnesses that need to be 'cured'. Should they be considered as such, though? The community college is the only higher education institution that "exemplify our nation's tradition of egalitarian and inclusive public education" (Grubb & Lazerson, 2004, p. B16) and therefore, they have to satisfactorily fulfill five *different* functions: vocational training, career shifting, adult enrichment, general education, and transfer. The review shows that in this setting mathematics departments are a key piece in fulfilling the general education and transfer functions: Students who take remedial (or developmental) education do as well as those who do not need such courses and both full-time and part-time faculty have comparable behaviors and similar impact on students. Missing in the literature are articles about how mathematics departments participate in fulfilling the colleges' vocational, career change, and adult education functions. Burn (2006) suggests that in trying to be more like four-year selective institutions, mathematics departments in U.S. community colleges might fail to capitalize on the potential of the students they educate: concentrating on what the students are not, rather on who the students are, only makes the inadequacies more salient, the possibilities for renewal more difficult (pp. 226-227). The absence of articles that talk about the mathematical instruction in vocational and career change programs or adult enrichment education suggests also that the general education and transfer functions are prioritized in this setting. Student success by necessity needs to be redefined when these other functions are taken into account. In other words, a blanket definition of student success not only can't possibly account for the different functions that the colleges must fulfill, it overlooks the widely different conditions in which students who attend community colleges have to operate, balancing work, family, and education. For many of these students, differently from their selective institutions peers, the community college is the only option they have to advance their education.

Conclusion

The lack of information about how instructors make day-to-day decisions makes the process of understanding instruction more difficult and therefore institutional intentions to improve students' success may fall short of addressing an important piece of that success, namely instruction. The community college, because of the diversity of both its student body and its course offerings, is the setting that presents with the better opportunities to study how

instructors make these decisions, how these decisions play out in the classroom, and how they affect students. Without a full understanding of what mathematics instruction encompass, measures of its effectiveness will continue to appear suspect, its impact on students' success questionable.

This review started with the intention of describing the role that mathematics instruction plays on students' success in community colleges. Given the growing pressures for the society to prepare their citizens for a changing economic world that requires knowledge of new skills, community colleges are called to assist in the massive retraining of the society's work force. In this setting questions of how to address the demands for learning of a changing student population must take precedence over other questions of success, especially if success is not tailored to the different functions the colleges have. Attention to the specific work that instructors do with students within their environment and with relevant mathematical content, together with attention to the role that resources can play in such process should be at the forefront of research in this setting.

The mathematics classroom in the community college is a setting that can push the boundaries of the applicability of what we know, precisely because it offers contextual conditions that are unique and strikingly different from both K-12 education and selective universities. We need to describe how mathematics instruction occurs in community colleges, that is, how do instructors organize the shared work on mathematics with their students in this setting? For example, what kind of planning do instructors carry out? How do they take into account students' prior knowledge? How do they select content, examples, or questions to present to the class? When do they 'lecture' and for what purposes? What kind of resources do they draw from in order to create their lessons? And inside classrooms, how do instructors provide explanations about mathematical ideas? What roles do students assume? How is knowledge constructed? How are students' questions handled? How are students invited to participate in the construction of knowledge? The descriptions should also account for whether there are differences depending on the level of the class, that is developmental, pre-college, or college courses.

Answers to these questions are urgently needed if we want to understand what it takes to teach mathematics in this setting and to ensure students subsequent success in this setting.

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