The Learning of Mathematics for Limited English Proficient Learners: Preparation of Doctoral Level Candidates

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Abstract

Across the United States, there is a growing number of students for whom English is not their first language. These students experience many challenges adjusting to new educational environments. These students are often denied access to the full curriculum in mathematics (Reyes & Fletcher, 2003) and the resulting opportunities for higher level educational experiences in mathematics and the resulting higher economic employment options. Educators need support in understanding and responding to the linguistic and cultural challenges that these students face in learning mathematics. A course entitled Language, Culture, Mathematics and the LEP Learner is part of the doctoral courses available to Curriculum and Instruction students at UNC Charlotte. The course focuses on theoretical and applied models of teaching and learning mathematics for English as Second Language Learners. Research and current practice are reviewed with an emphasis on the design, implementation, and assessment of instruction for this population of learners. A qualitative analysis of students' final research projects using narrative analysis methodologies showed that students (1) position issues within a larger sociocultural framework (2) advocate for the negotiation of pedagogical principles that blend language learning strategies with effective mathematics pedagogy and (3) identify assessment policies and processes that are supportive and limiting for these learners.

Introduction

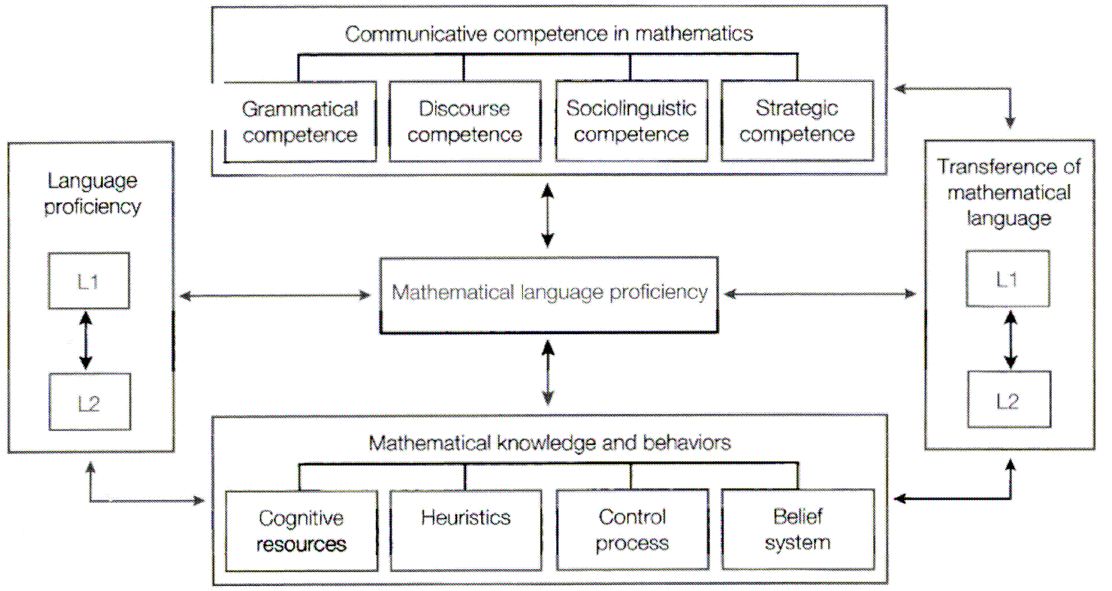
Language and culture provide a dynamic system which influences teaching and learning. Learning mathematics requires multiple and complex linguistic skills that second language learners may not have mastered (Cuevas, 1984). An emphasis on language in the teaching and learning of mathematics is essential if English Language Learners (ELL) is to have access to the technical careers that require a solid background in mathematics and science. In today's mathematics classrooms, students must deal with communication demands (oral and written) that require participation in mathematical practices such as explaining solution processing, making and describing conjectures, proving conclusions and presenting arguments and justifications. These processes are in addition to those related to acquiring technical vocabulary, developing comprehension skills necessary to read and understand various mathematics texts, or in solving 'word' problems (Moschkovich, 2002).

The complexity of the relationship between language and mathematics learning becomes evident through a situated sociocultural lens. Moschkovich (2002) identified several communication components that only become visible through such lens: (1) Participation in mathematical discourse moves beyond learning vocabulary to participating in the use of discourse practices such as using representations to support claims; (2) Students may use gestures, objects, everyday experiences, first language, code switching and multiple mathematical representations; (3) There are multiple uses of bilingual conversations between students such as labeling objects or explaining a concept, justifying an answer, or describing a mathematical situation; (4) Students bring varied competencies into the classroom and may be proficient at presenting clear arguments or using mathematical constructions though their vocabulary may be inadequate.

Olivares (1996) identified three characteristics, for non-native speakers of the language, in which communication in mathematics differs from everyday communication. First, students are required to work with abstractions and symbols that do not typically facilitate comprehension in everyday speech. Second, each element of a proposition is essential for understanding the entire proposition. Understanding or making inferences without fully understanding each part is practically impossible. Third, elements of mathematics propositions often have such specificity

that they cannot be rearranged. Olivares' model of communicative competence in mathematics emphasizes the complexity of the language-mathematics connection.

Figure 1. Communicative Competence in Mathematics (Olivares, 1996, p. 221)



The importance of language in mathematical discourse is evident from the above discussion. Assessment becomes an additional component that requires a command of academic English and the register for mathematics. Consider the following example from a state high school exit exam (Filmore, 2002, p.3).

If **x** is always positive and y is always negative, then **xy** is always negative. Based on the given information, which of the following conjectures is valid?

A. $x^n y^n$, where *n* is an odd natural number will always be negative.

B $x^n y^n$, where *n* is an even natural number, will always be negative.

C. $x^n y^{m,}$ where *n* and *m are* distinct odd natural numbers, will always be positive.

D. $x^n y^m$ where *n* and *m* are distinct even natural numbers will always be negative.

What does success with such an item require? Students must be competent in dealing with exponents and multiplication of integers; use logical reasoning; be familiar with the structure of conditional sentences; know the meaning of technical terms such as negative, positive, natural, odd, and even in relation to discussions about numbers; and know frequently used words such as if, always, then, where, based on, given information, the following, conjecture, distinct, and valid.

Description of the Course

The course, EDCI 8020: Language, Culture, Mathematics and the LEP Learner, focused on theoretical and applied models of teaching and learning mathematics for English as Second Language Learners. Research and current practices served as a foundation for discussions and readings. Research and theoretical perspectives were reviewed with an emphasis on the design, implementation, and assessment of instruction for this population of learners. The major goals of the course were to

1. Trace the legal, historical, and political context of ESL in the United States.
2. Describe the theoretical underpinnings of ESL and the language and mathematics connection.
3. Identify best instructional practices for ESL mathematics learners based on current research and curriculum theory

4. Describe and analyze assessment practices and issues in mathematics related to ESL learners.
5. Develop an instructional intervention for ESL learners, including a paper framing the intervention in a theoretical and research base.

Participants

The participants were six doctoral students enrolled in a curriculum and instruction program with one specializing in urban education, three in literacy education, and two in mathematics education. The five females and six males had a wide range of teaching experiences at both the elementary and secondary level ranging from four years to more than twenty years of classroom experience. Two of the participants were administrators in school districts, one worked for a city agency, and one was a lecturer at the university.

Research Design

Narrative text analysis of documents was selected as the appropriate methodology to understand students' perceptions and applications related to the course content (Qualitative methods using content analysis of student papers to identify patterns, core constructs, and themes related to student's projects was the overarching method. The researchers agreed that the sentence would be the primary unit of analysis though several sentences might be chunked if appropriate to preserve meaning. The segmentation procedure was therefore focused on units of meaning whether they were partial, complete or multiple sentences that represented a consistent idea, argument chain or discussion topic (Chi, 1997). The units were then categorized into pedagogical principles, philosophical and theoretical concepts, tasks related to instruction, assessment or student learning. Once the data from the students' papers were analyzed and coded, the researchers met to debrief about the process and to resolve issues related to the categorization of the segmented units. The resulting data provided the students' perceptions and hopes relative to the teaching and learning of mathematics for limited English proficient learners.

Results

The results of the narrative text analysis provided descriptions of the students' thinking relative to three themes: (1) the sociocultural nature of language issues (2) knowledge of pedagogical principles that blend language learning strategies with effective mathematics pedagogy and (3) an awareness of how assessment policies both support and hinder ELL learners.

Sociocultural Nature of Language Issues

The first results discussed demonstrate that participants in the study, position issues within a larger sociocultural framework. There was agreement among all of the participants that beginning teachers are not given adequate training prior to teaching and support while teaching, to be able to accommodate ESL students in U.S. classrooms. The notion that teachers can be outstanding academics in their area of expertise, but lack an understanding and training in the emerging linguistic needs of their ESL students was also evident in the responses that we received. A recurring theme among participants was that the United States employs a large immigrant population to sustain their economic prosperity, and thus is obliged to educate the children of immigrants.

The students' responses consistently reflected and discussed constructivist ideas and philosophies. Such learning theories were directly related to classroom practices.

> The constructivist learning environment can be better suited for supporting the ELL by incorporating the following strategies: bilingual instruction, access to opportunities where ELLs can share their home culture, the allowance of ESL students process new ideas in their home language, using resources that increase the dialogue between the teacher and the ESL student, utilizing culturally responsive instructional methods, diagnostic reform, and consciously planning instruction using Vygotsky's Zone of Proximal Development.

An emphasis on classroom communication must be "continuous and ongoing". LEP students often face barriers to participation in constructivist environments. Mathematics is a unique

language that is highly symbolic and abstract requiring students to master vocabulary, sentence structure, and interpretation of illustrations (see Usiskin, 1996)

The importance of sociocultural awareness as an integral part of an effective teacher preparation program was mentioned in all the papers acknowledging a problem or promoting more focused preparation. One high school teacher offered, "While a novice teacher at the high school level, I ascertained quickly that high school teachers were generally stellar academics in their areas of expertise, but many lacked an understanding of, and any training in, how to reach students' developmental academic levels and emerging linguistic levels." Another student suggested that all pre-service and in-service teachers receive ELL training. She proposed an emphasis on coursework and field work in language acquisition, language development, cultural diversity, and methodology including possibilities of study abroad programs, participation in community service, and learning a second language.

Pedagogical Principles Blending Language with Mathematics Pedagogy

Students offered multiple approaches to effectively deal with language issues in mathematics such as collaborative learning, contextual assignments, reading mathematics, problem-solving, teacher collaboration, and the use of effective reading programs and expressive gestures. There was also an elucidation on the importance of the teacher being involved in classroom discourse by offering opportunities to discuss strategies and sharing of ideas, both between the teacher and students but also among the students. Such practices were viewed as being central to the development of metacognition which was identified as an essential cognitive process to LEP students to develop if they are to be "full participants in the complex communicative environment of the mathematics classroom". A second cognitive principle that appeared in several papers was the importance of scaffolding coupled with explicit strategy instruction for ELL students.

A common thread among the papers was the power of such practices to transform the learning opportunities not only for ELL students but for all students. The following excerpt from one of the students is indicative of how all the students viewed the pedagogical principles identified as effective with ELL learners.

> It seems the strategies discussed for ELL learners cannot be simply implied for ELL students. They are strategies that any teacher can use to be an effective classroom teacher and are simply strategies of good teaching. "Good teaching is teaching for all. These strategies will help ELLs, but they will help typical learners as well" (Drucker, 2003, p. 22). By imposing these strategies on traditional English speaking students, they will not become less educated, but they will become better learners. Popkewitz (2004) implies that there is no magic solution to teaching ELL students, but it is a mixture of many important things. The most important ingredient of all: Good teachers who communicate to all students that they care.

Assessment Policies and ELL Learners

Participants identified assessment policies and processes that are supportive as well as well as those that are limiting for ESL learners. Referring to the size of the ESL population and the lack of teacher training in U.S. public schools, one participant stated that, the sheer size of the school population, "Should drive policy reform at the national and state levels to include intensive coursework in English as a Second Language for all current and prospective teachers." Another set of solutions referred to the assessment practices of educators and the need to teach test-taking strategies to ESL students. One participant summed it up by saying, "In an era of high stakes testing, we do students a disservice unless we explicitly teach them how to take tests. These strategies should focus on larger areas of cognition, language function and higher order thinking, which will not only improve performance on standardized assessments, but also serve the student as a lifelong learner." A theme that ran through most of the papers was the notion that we test immigrant children on what is valued in American schools, and ignore the learning they bring from their home country, which may reflect different values. Participants stated that these results do not necessarily indicate a lack of proficiency on the part of the non-English speaking child. One participant stated that not accounting for knowledge of other languages and cultures when being tested, "Results in an

improper diagnosis of deficient learning. Diagnostic practices need to change to reflect a better assessment of the cognitive abilities of all immigrant children."

The students believed that policy reform at both the national and state levels was necessary to address the needs of this "significant segment of the school population". One underlying problem that was identified was the lack of assessments that allow ELL students to demonstrate their cognitive abilities. Such lack of appropriate assessments may result in "ESL children tend[ing] to be placed in classes that focus on developing computational skills and place little emphasis on problem solving strategies even though their overall cognitive abilities may be higher" (see Chamot, 1992). Such practices present a "deficit model" of cognition for many immigrant students.

Conclusions

There are numerous and complex issues related to the teaching and learning of mathematics for ELL students. This course provides a crucial link to address access issues for students who do not speak the native language of instruction. As one teacher in the class confided:

> As a high school classroom teacher I can admit that, until the writing of this paper, I was not aware of the myriad of issues facing multilingual students, especially in the mathematics classroom. In my opinion the mindset that mathematics is universal is no longer true (and perhaps it never was).

But it is about more than raising awareness. There must be deliberate and research-based efforts to address the problems that the students face when struggling with language issues as they learn mathematics. As pointed out by the students in this course, such practices are just 'good teaching' and hold potential not only to positively affect ELL learners but all students. As teachers, administrators, and other professionals become aware of the sociocultural nature of mathematics teaching and learning and struggle with the pedagogical and assessment issues related to ELL learners, there is a nucleus of awareness raising that has the potential to begin a wave of reform to change our approaches and our beliefs in providing all students with opportunities to develop their full mathematical potential.

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