Bridging the Language Barrier in Mathematics

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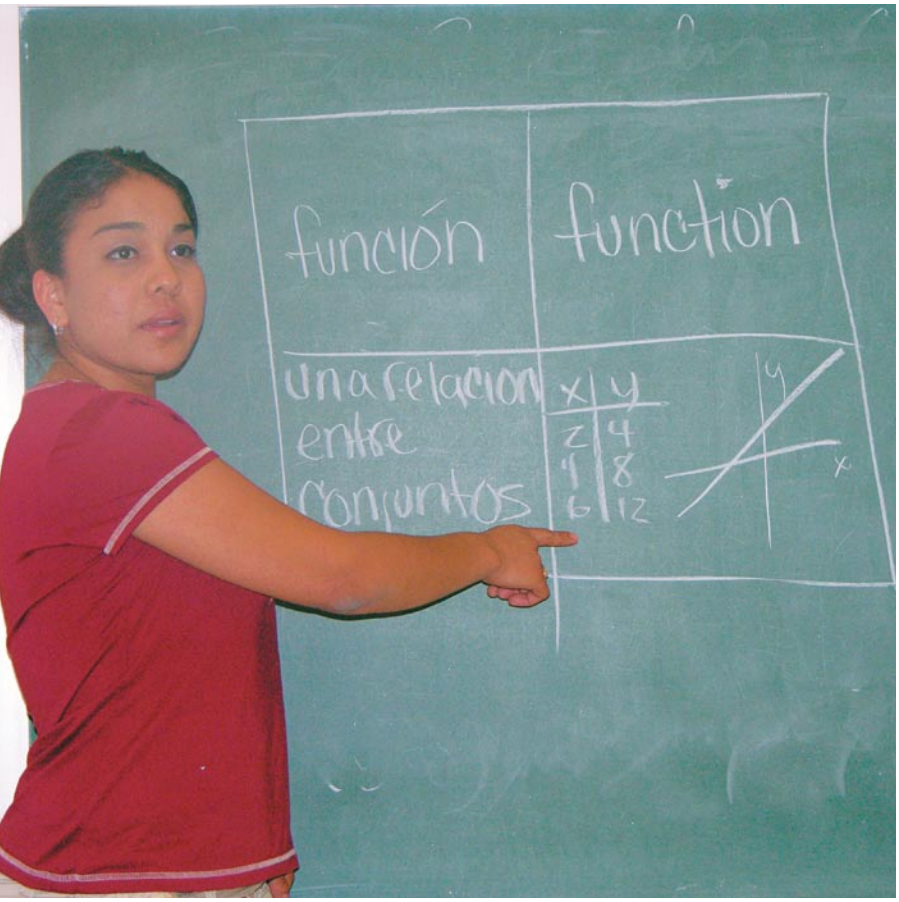

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Teaching mathematics to English Language Learners (ELL students) has become a challenge faced by an increasing number of U.S. teachers. Between 1979 and 2004, the number of K–12 students who spoke a language other than English at home increased from 3.8 million to 9.9 million. During that same time, the number of K–12 students who had difficulty speaking English increased from 1.3 million to 2.8 million (U.S. Department of Education 2006). Even teachers who may speak a second language still face the daunting task of teaching mathematics effectively to ELL students. I was one of those teachers. From 1995 to 1999, I taught at a high school in Southern California where the student population was 56 percent Hispanic. I spoke Spanish and was hired in part to teach mathematics to ELL students. I taught my classes in English. My school had no materials for use in an ELL class with Spanish speakers, and I could not find a textbook company that offered such materials. I was also not eager to spend enormous amounts of time trying to translate mathematics texts.

As a result, I began a quest to find ways to help my ELL students learn mathematics. My initial hypothesis was that the main barrier for these students was learning mathematics in their new lan-

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guage. I decided to look at research regarding both how one learns a new language and how one learns mathematics, thinking that I could use any similarities between the two bodies of research to come up with a teaching method. I found three similarities: Students learn a new language and mathematics more effectively when—

- they write to communicate what they are learning (Calder 1995; Chastain 1988; Fagan 1995; NCTM 1989, 2000; Silver and Kenney 1995);
- they learn in groups (Good, Mulryan, and McCaslin 1992; NCTM 1989, 2000; Olsen and Kagan 1992; Paulston and Britanik 1995); and
- the learning is set in context (that is, when real-life settings are used) (Bourque and Jacques 1995; Chastain 1988; Secada 1992).

By synthesizing the research, I created an approach for teaching ELL students mathematics, which I called Mathematics as a Second Language (MSL). The main components of MSL are vocabulary activities, journals, group work, and projects. I used MSL to teach prealgebra to my ELL students as well as to my native English speakers, for two reasons. First, I wanted to compare the mathematical performance of my ELL students with that of native English speakers; to do so, I needed to use the same approach with both classes. Second, it seemed that focusing on the mathematical language would be beneficial to all students, regardless of their first language.

Brenner (1994) suggested a three-part framework for the forms of mathematical communication: communicating about mathematics, communicating in mathematics, and communicating with mathematics. I based my research questions about MSL on Brenner's work. First, would MSL help students communicate more effectively *about* mathematics? In other words, would students be able to describe their own problem-solving processes and their thoughts about those processes? Second, would MSL help students communicate more effectively *in* mathematics? Communicating in mathematics requires that students effectively use the language and symbols of mathematical convention. Finally, would MSL help students communicate *with* mathematics? Communicating with mathematics refers to using mathematics as a tool in solving meaningful problems.

To assess whether the goals of MSL were met, I used several sources of data. First, I conducted pre- and posttests on vocabulary and mathematics to see if there had been growth in learning. I also used scoring rubrics from journals to look for improved mathematical communication. Another source of data was scores from students' mathematics projects. The projects, which showed how students might use mathematics as a tool to solve real-life problems, were scored using a rubric that focused

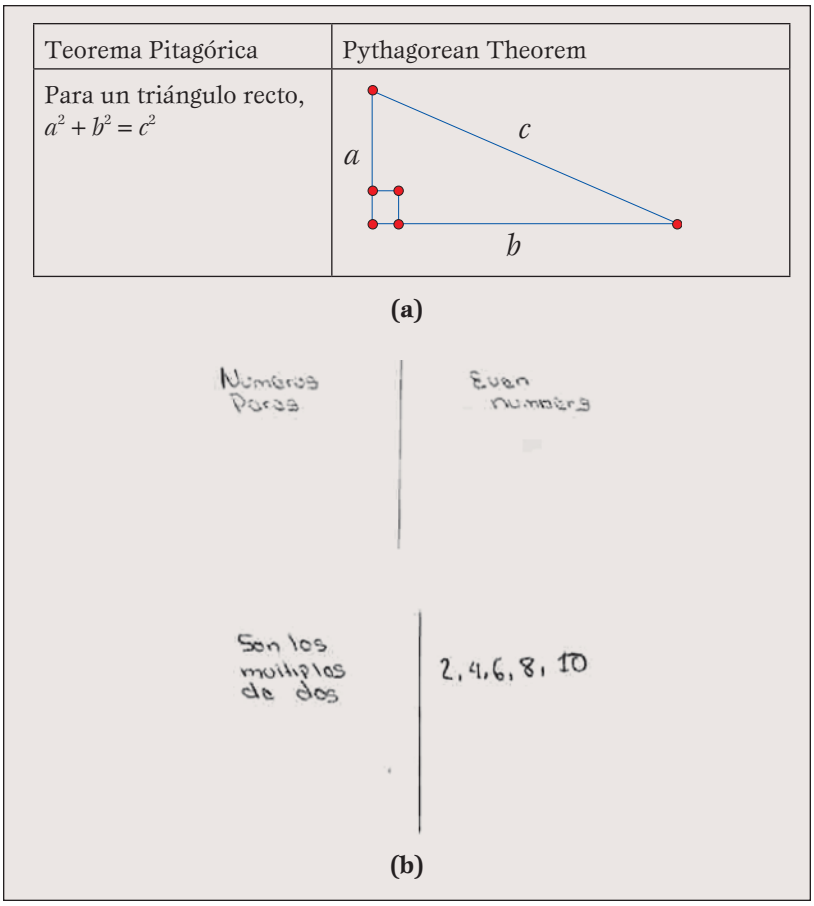


Fig. 1(a) Geometry Word Square; **(b)** ELL student's Word Square

partly on students' mathematical communication. I also used my own observations and research journal as a final source of data to determine the effectiveness of MSL.

In the remainder of the article, I describe how students reacted to the various components of MSL. I present one vocabulary activity that seemed to be effective with my students and explain certain aspects of group work that I found necessary to implement for ELL students to negotiate mathematical situations successfully. I then describe how my students reacted to journals and projects without giving the specifics of how I implemented these, since both are common to Standards-based teaching (see NCTM 2000). Finally, I make recommendations for teachers who speak only English and teach ELL students.

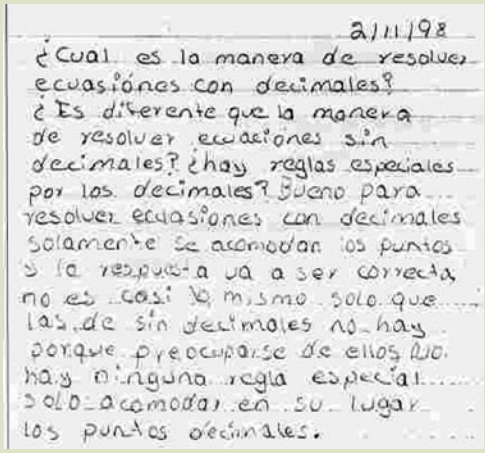
WORD SQUARES

Word Squares (Quinn and Molloy 1992), an activity that aims to help students learn mathematical vocabulary, was one of the more successful ones I used with students. In Word Squares, students take a 3 × 5 card and divide it into four quadrants. (See **fig. 1a** for an example from geometry and **fig. 1b** for an example of one of my students' Word Squares.) In the upper left quadrant of the Word Square, students write the mathematical term in their own language (which, in the case of my students, was Spanish). In the upper right quadrant, students write the mathematical term in English. In the lower left quadrant, they write the definition of the mathematical term in whichever language they understand best. The definition was to be in the students' own words, not just copied from the textbook; in **figure 1b**, the student chose to write the definition in Spanish. In the lower right quadrant of the Word Square, students include a representation of the mathematical concept. In **figure 1b**, the mathematical term was *even numbers*, so the student included some examples of even numbers. In other Word Squares, students drew figures, made tables, or included graphs as visual representations of the mathematics terms.

Using Word Squares with my ELL students had several benefits. First, completing a Word Square required more of them than just memorizing a definition. Students had to understand the definition in order to put it into their own words. Moreover, they had to understand the concept in order to choose an effective representation for the mathematical term. In essence, the Word Squares acted as a condensed set of mathematical notes. The students could keep the Word Squares with them all year, a component of MSL that allowed them to review concepts when necessary and gave them easy access to mathematical concepts even when they were not in my class. In fact, many students used their Word Squares in their mathematics classes the following year. Because I was the only mathematics teacher on my campus who spoke Spanish, students did not have language support from their other mathematics teachers, and the Word Squares helped when they could not remember the mathematics terms in English.

GROUP WORK

My review of the research showed that for ELL students working in groups, three factors mattered. First, students within the groups should not be homogeneous in their language ability. Students of different language ability need to interact in order to improve the group's mathematical communication. Next, the groups' composition needs to change periodically so that students do not become complacent with group work. Varying the groups' makeup also gives students the chance to gain insight from many different students' mathematical points of view. Finally, students need to learn how to participate in groups. ELL students have likely not participated in the type of group work most teachers may use. Rather than assume that they are adept at working in groups, and thus set them up for marginal success in your classroom, take time to teach ELL students how to work in groups.



2/11/98
¿Cual es la manera de resolver ecuasiones con decimales? ¿Es diferente que la manera de resolver ecuaciones sin decimales? ¿hay reglas especiales por los decimales? Bueno para resolver ecuasiones con decimales solamente se acomodan los puntos y la respuesta va a ser correcta no es casi lo mismo solo que las de sin decimales no hay porque preocuparse de ellos no hay ninguna regla especial solo acomodar en su lugar los puntos decimales.

(a)

What is the method for solving equations with decimals? Is it different than the method for solving equations without decimals? Are there special rules for decimals? Well, to solve equations with decimals you only have to arrange the decimal points and the answer is going to be correct. No, it is almost the same, only for ones without decimals you do not have to worry about them (the decimal points). There is no special rule, only put the decimal points in their place.

(b)

Fig. 2 (a) Excerpt from an ELL student's journal; **(b)** translation of this student's journal

Implementing group work in ELL classrooms had several effects on student learning. First, I observed that students' use of mathematical terms in English increased. Our class culture encouraged students to use English as much as possible, and students enthusiastically took on the challenge of referring to mathematical terms in English. At the end of the school year, many students were using mostly English to talk about the mathematics they were doing in their group. Second, student communication became more mathematical. At the beginning of the school year, students would ask questions such as, "What did you get on number three?" At the end of the school year, student questions were more like this one: "Why is it that you got the answer you did? I solved mine differently from yours, and this is why it works." Last, students' mathematical understanding increased. Students who were more fluent in English had the opportunity to help peers who were less fluent. The more fluent students gained a deeper understanding of the mathematics because teaching a mathematics concept requires a deeper understanding of mathematics (Ma 1999). The less fluent students had the advantage of reviewing the mathematics content with someone who spoke their native language.

Score	Rationale
0	No work
1	Cannot understand entry
2	Some understanding of entry, perhaps off topic
3	Complete understanding of entry, on topic

Fig. 3 Rubric for journal evaluation

JOURNALS

Writing in journals was another approach I used to help ELL students learn mathematics and the language of mathematics at the same time. Students were allowed to write in the language they felt most comfortable with, but they were required to write the mathematical terms in English. I felt that they could start to use the mathematical terms in English even though they were communicating about these terms in their own language. Using the mathematics terms in English helped students associate the English term with the mathematical concept already in their minds in Spanish. See **figure 2** for examples of journal entries.

An integral part of the journal activity was evaluation. At the end of each week, students evaluated their peers' journals using a simple three-point rubric (see **fig. 3**). Students would exchange journals with a partner, assign a score to the journal entry, and give a written rationale for their score. The journal writer then had the opportunity to read and respond to the journal evaluation using the same rubric. Therefore, students received two scores, one for their own journal entry and one for their evaluation of their peer's journal entry.

ELL students benefited from journal writing in a number of ways. First, writing about the mathematics forced them to decide what they did and did not understand and to put those thoughts on paper. Many commented that writing in their journals helped them understand the mathematics better. Next, students became more proficient in communicating mathematically. Their first journal entries were often unsophisticated, relying on nonmathematical terms to express their ideas. As the year progressed, their journal entries became more mathematically precise. Of equal importance, students used English more frequently in their journals. Student evaluation of journals was an effective, rewarding activity. Students put more effort into their journal entries because they knew

that their peers would be reading them. Further, students would often discuss one another's evaluations when they did not agree with or understand the evaluation. The discussions were always mathematical in nature, because students had to explain their reasoning to their peers.

PROJECTS

When working on projects, my ELL students did not seem to realize that they were doing mathematics, even though the mathematics requirements for the projects were rigorous. Because the projects focused on real-life topics, such as the stock market or current social issues, students were engaged and motivated to learn the mathematics necessary to complete their projects.

Furthermore, students started to see the benefits of using mathematics in their lives. As part of a stock market project, one group of students invested all their money in a popular shoe company. Unfortunately, the shoe company was going through some hard times, and as the students were completing the project, the company's stock dropped considerably. In their report, my students noted that they now hated the shoe company and would never wear that type of shoe again. However, they also saw that by understanding the mathematics they could make informed decisions about stock purchases.

The projects also helped increase mathematical communication in the classroom. I gave my students several opportunities to work on the projects in class. While they worked, I would circulate in the classroom and talk with them about their projects, questioning them about their ideas and decisions. Thus, students could work through their ideas and try to express them clearly to me well before they presented them to the class. By the time they presented their projects, they could clearly communicate their mathematical ideas.

DID MSL WORK?

The most important questions asked about MSL were, Did it work? and Were the research questions satisfactorily answered? The answers are resounding maybes. MSL did seem to promote communication about mathematics. When I first implemented MSL, at the beginning of the school year, all mathematical communication in my classroom was teacher initiated; at the end of the school year, the majority of mathematical communication was student initiated. The type and quality of mathematical communication also seemed to change. Instead of asking what the answer was for a particular problem, students would ask for solution methods as well as offer their own methods for examination.

MSL also seemed to improve communication in mathematics. Students seemed to be learning and using the mathematical vocabulary more effec-

tively, as evidenced by the improvement in vocabulary quiz scores and the increased proper use of mathematical terms in students' journals and classroom discussion. Moreover, students correctly used mathematical terms in their presentations about their projects.

One area in which MSL was not as successful was helping ELL students communicate through mathematics. Seeing mathematics as a useful tool for everyday life takes time, and I was unable to commit enough time to projects to give a definitive answer as to whether MSL met its third goal.

WHAT IF YOU DO NOT SPEAK THE LANGUAGE?

Many readers may feel that my success with ELL students was due to my ability to speak Spanish. Speaking Spanish was a huge advantage when working with ELL students. Nevertheless, one can successfully teach mathematics to ELL students even if one does not speak the language. Group work is vital to success in teaching ELL students. Generally, each ELL classroom will have a few students fluent enough to understand a teacher's English. I made those students my assistants in the classroom. I assigned each one to a group, giving them the responsibility to help communicate the lesson's mathematics to their peers. This did not mean translating the lesson into Spanish but leading mathematical discussions with their peers. The majority of my assistants worked out well and felt a sense of pride when their peers learned the mathematics.

Another resource for teachers who do not speak the language is glossaries in the second language. Many textbooks have a Spanish glossary of mathematical terms as a part of the ancillary materials. Also available are online Spanish-English dictionaries such as www.spanishdict.com/. Another useful resource is "Mathematics as a Second Language Glossary" (Pagni and Castellanos 2004), published by COMAP (www.comap.com). These glossaries provide a starting point for communication. Even though I spoke Spanish, I had not learned many of the mathematical terms in Spanish; therefore, a glossary of terms was invaluable to me.

A bilingual aide can be priceless when working with ELL students. Even though I spoke Spanish, I asked for the help of the school's bilingual aide. She had been taught how to help ELL students learn English and was a great asset when I was trying to construct some vocabulary activities. Furthermore, this aide could also circulate in the classroom, asking questions and motivating students. I met regularly with the bilingual aide so that she knew what MSL's mathematical goals were and how I wanted students to work in my classroom.

Another possible resource is foreign language teachers, who have been trained to teach others a new language. They are knowledgeable about activities and methods to help students learn vocabulary and also know how to put learning in context. Often, foreign language teachers will speak completely in the foreign language while teaching their students; it is through contextual clues, such as pictures or teachers' actions, that students learn the new language. The activities used in the foreign language classes can be adapted for use in the mathematics classroom.

A final idea for teachers who do not speak their students' language is to learn it. I am not suggesting that you have to become fluent in the students' language in order to teach them successfully, but learning enough of their language so that you can greet them and ask them how they are goes a long way toward gaining their confidence. Attending school in a foreign country and using a language that you do not know can be daunting. Those who have traveled might be able to identify with this feeling. Making the effort to help students feel comfortable by speaking in their own language will inspire them to make an effort to learn mathematics in your class. Show ELL students that you care about them, and they will trust you more and work harder for you.

OTHER RESOURCES

Some of the groups that work on understanding how to help ELL students learn mathematics are TODOS: Mathematics for All (www.todos-math.org/); Center for the Mathematics Education of Latinos/as (CEMELA, math.arizona.edu/~cemela/english/); and the Texas State University System Mathematics for English Language Learners (www.tsusmell.org/). These groups research how to teach ELL students mathematics, hold conferences to discuss and disseminate their findings, and offer teacher resources on their Web sites.

CONCLUSION

Effectively teaching ELL students mathematics is hard work, although the methods are not that different from effective methods for teaching English-speaking students mathematics. *Principles and Standards for School Mathematics* (NCTM 2000) states that students should be able to—

- organize and consolidate their mathematical thinking through communication;
- communicate their mathematical thinking coherently and clearly to peers, teachers, and others;
- analyze and evaluate the mathematical thinking and strategies of others;
- use the language of mathematics to express mathematical ideas precisely. (p. 60)

Through my synthesis of the research, I found that ELL students need the same opportunities to communicate mathematically. Moreover, my findings about MSL seemed to confirm that ELL students, in order to learn mathematics as well as English, must have the chance to communicate mathematically. A student-centered teacher who espouses NCTM's *Principles and Standards for School Mathematics* will not have to change too much in order to have success with ELL students.

One can successfully teach mathematics to ELL students even if one does not speak the language

MSL is a work in progress. Since completing my original action research project, I have learned that ELL students face other challenges when learning mathematics—for example, ELL students' mathematical ability in their native language affects their ability to learn mathematics in their second language. Because improving the mathematical education of ELL students is every teacher's responsibility, I invite readers to try some of the MSL activities. If we address this challenge together, we can provide high-quality mathematics education for all students.

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