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Mathematics Teaching and Learning for English Language Learners

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A common misconception about mathematics is that it is a "universal language" and is "culture-free." This misconception ignores the vital role of academic language in the development of important mathematical processes and practices highlighted in standards.

Standards-based mathematics instruction emphasizes the need for students to be able to read mathematics, explain their mathematical thinking (orally and in writing), and understand the approaches of others in solving mathematics problems. Having English Language Learners (ELLs) share their mathematical thinking positions them as competent problem solvers and, thus, contributors of mathematical knowledge, and it places them on a trajectory for increased participation in the learning process (Empson, 2003).

The National Council of Teachers of Mathematics (NCTM) communication process standard calls for instructional programs that enable all students 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.

It is important for all students, but especially critical for ELL students, to have opportunities to speak, write, read, and listen in mathematics classes, with teachers providing appropriate support and encouragement (NCTM, 2000).

The Common Core State Standards (CCSS) for mathematical practice indicate that mathematically proficient students explain their thinking in problem solving, listen to and understand approaches of others to solving complex problems, justify and interpret their mathematical results, and communicate precisely to others (National Governors Association, 2010).

Given these CCSS and NCTM Process Standards, there is a need to consider principles specific for ELLs to engage in mathematical discourse that fosters the learning of rigorous mathematics (Ramirez & Celedon-Pattichis, 2012). Researchers from the Fostering Mathematics Success of English Language Learners (FMSELL) project identify three key principles of effective instruction that secure opportunities for ELLs to learn mathematics:

1. Challenging mathematical tasks. It is important and possible for students at all levels of language proficiency to engage in challenging and worthwhile mathematical tasks on a regular basis. The tasks can be made more accessible through supports that help clarify students' understanding. Furthermore, the tasks should include significant mathematics that challenges students to reason mathematically and solve problems. "Challenging mathematical tasks" refers to "high cognitive demand tasks" as described by the Quasar Project—tasks that involve students in doing mathematics or using procedures with awareness of connections to their underlying mathematical meaning (Silver & Stein, 1996; Stein et al., 2000).

2. Representation using multiple modes. The use of multiple modes (pictures, diagrams, presentations, written explanations, and gestures) gives students a way to understand the mathematics and express their thinking in problem solving. Mathematical tools and modeling are then a resource for all students, and especially ELLs, to engage in mathematics and communicate mathematically.

3. Academic language. All students can learn to express their mathematical thinking and reasoning in precise academic English, engaging productively in mathematical discourse. Communication about mathematical reasoning and problem solving relies on academic language for the precision required. There needs to be support for ELLs in learning the academic language of mathematics, taking into consideration linguistic demands in making mathematics comprehensible.

Using the principles noted above and remembering cultural and linguistic differences as intellectual resources, we consider what researchers and practitioners recognize as effective strategies for engaging and supporting ELLs in the mathematics classroom. Mathematics instruction for ELLs should follow recommendations for high-quality mathematics instruction and teaching mathematics for understanding. Teaching that makes a difference in student achievement and promotes conceptual understanding has two central features: (1) teachers and students attend explicitly to connections and concepts, and (2) teachers give students time to wrestle with important mathematics (Hiebert & Grouws, 2007). A prescription to keep in mind is the fact that effective mathematics instruction for native English speakers is similarly effective for ELLs, provided

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that specific attention is given to bridging language difficulties.

Research-based strategies that are key toward supporting ELLs' mathematics proficiency include the following:

1. Connect mathematics with students' life experiences and existing knowledge (Barwell, 2003; Secada & De La Cruz, 1996). It is essential to take into account students' unique experiences, prior learning, and individual strengths, as these contribute to their mathematics learning. This strategy suggests using students' experiences and prior knowledge to create contexts for instruction that are meaningful and motivational. Being aware of student backgrounds and prior knowledge will help ELL students know that their experiences and culture are valued.

2. Create classroom environments that are rich in language and mathematics content (Anstrom, 1997; Khisty & Chval, 2002). This includes treating students' language as a resource, involving everyday ways of communicating in mathematical discourse. Cultural and linguistic differences are viewed as intellectual resources to connect prior knowledge and provide opportunities for students to learn mathematics (Ramirez & Celedon-Pattichis, 2012).

3. Emphasize meaning and the multiple meanings of words. Students may need to communicate meaning by using gestures, drawings, or their first language while they develop command of the English language and mathematics (Morales, Khisty, & Chval, 2003; Moschkovich, 2002). There are a number of tips for explicitly teaching mathematical academic vocabulary. For example:

- Demonstrate that vocabulary can have multiple meanings, helping students understand different meanings and how to use them correctly in mathematics.
- Encourage students to offer bilingual support to each other, especially for students who will benefit from hearing an explanation in their first language.
- Identify key phrases or new vocabulary to pre-teach.
- Offer students objects and images to portray and master vocabulary.
- Use vocabulary strategies such as concept circles, Frayer models, and word sorts.

4. Use visual supports such as concrete objects, videos, illustrations, and gestures in classroom conversations (Moschkovich, 2002; Raborn, 1995).

5. Utilize a variety of learning modalities in teaching mathematics concepts and skills (Williams, 2009). For example:

- Provide a variety of manipulatives and use them purposefully.
- Teach rote concepts through songs or rhymes.
- Use movement to reinforce concepts.
- Explore math concepts with art projects.
- Access technology; provide time for use of problem-solving or skill-building programs on the computer; and explore calculators.

6. Connect language with mathematical representations (e.g., pictures, tables, graphs, equations) (Khisty & Chval, 2002).

7. Write essential ideas, concepts, representations, and words on the board without erasing so that students can refer to them throughout the lesson (Stigler, Fernandez, & Yoshida, 1996).

8. Use pairs or small groups as an instructional strategy. Consider language and mathematics skills when grouping students (Winsor, 2007).

9. Discuss examples of students' mathematical writing and provide opportunities for students to revise their writing (Chval & Khisty, 2009).

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