

Mathematical Language

Opportunities to Build Students'

Intellectual Capacity

Research Summary

Cummins's research is instrumental in the identification of the construct of academic language as well as the distinction that the level of language proficiency in informal, interpersonal conversation occurs prior to cognitive academic language proficiency (Cummins, 1981, 1984). Subsequently, researchers have examined the connection between the understanding of academic language used during classroom instruction and its impact on students' academic achievement (Chamot & O'Malley, 1986, 1987, 1994; Collier, 1989; Cummins, 1981; Spolsky, 1989; Saville-Troike, 1991). Research reports that the vocabulary that takes on a different meaning in mathematics requires that students be skilled in learning the discipline-specific language of mathematics (Dale & Cuevas, 1992; Halliday & Martin, 1993; Kang & Pham, 1995; Lemke, 1990). Researchers such as Mestre (1988), Khisty (1995), and Moschkovich (2000) bring to the forefront the struggles that English-language learners (ELLs) confront with the linguistic features and specialized meaning of mathematical terms. Moschkovich's (2002) research emphasizes utilizing students' resources, e.g., the use of gestures to communicate as opportunities to support students' success.

The Complexities of Mathematical Language

Traditionally mathematics has been considered to be an international language of notations (signs and symbols), requiring minimal language (Dale & Cuevas, 1992). Examination of the following mathematical events is illustrative that building students' intellectual capacity to comprehend the discipline-specific language of mathematics is crucial for experiencing academic success.

Event #1: The classroom teacher verbalizes the following instructions: "What is the *sum* of 23 and 4?" The students cannot use visual cues to interpret the meaning, e.g., seeing the mathematical symbol (+) in written form, and are required to construct the quantitative problem $23 + 4$. Accurately completing this task entails several linguistic processes. Students must discern the polysemous or multiple meaning of the following words: *sum* (total) from the word *some* and the digit *four* from the words *for* and *fore*. To further complicate matters, the mathematical operation of addition is not limited to the term *sum*, e.g., *add* and/or *plus*.



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Event #2: Students engage in mathematical discourse with peers and the teacher to share the method they employed to calculate the *sum*. Effectively communicating (verbally or in writing) their mathematical thinking, problem-solving strategies, and results requires that students use mathematical language.

Mathematics and language are inexorably linked (Dale & Cuevas, 1992). Successfully engaging in these events requires that students accurately understand and interpret academic, mathematically situated language—the precise meaning of the terms *sum*, *four*, *addition*. These terms are only a few of the plethora of specific and specialized vocabulary that comprise mathematical language and are referred to as the mathematical register (Ron, 1999).

Oftentimes, students are confused as they attempt to accurately understand and interpret the meaning of a word in everyday conversation, e.g., “Please turn down the *volume* on the television set” and another meaning in the mathematical register, e.g., “What is the *volume* of this cube?” It is evident from the following translation of the foregoing sentences that use of the Spanish language is no exception. “Bájale al *volumen* de la televisión. Calcula el *volumen* del siguiente cubo.” This is due, in part, to the differences between mathematical language and the language used during conversations in daily lives (Ron, 1999). Fluency in interpersonal conversation does not equate to fluency in concepts and the discipline-specific language of mathematics.

The meanings of words such as *square*, *cube*, *second*, and *third* are dependent on their context within the mathematics lesson (Gibbs & Orton, 1994). Imagine the confusion for some students as they struggle to understand the following verbal directions from their teacher during mathematics: “Calculate how many *seconds* there are in 10 minutes. Calculate how many apples are in the *second* basket.” “Describe the characteristics of a *square*. What is the *square root* of 12?” During a science lesson the teacher verbalizes, “Describe how *roots* transport nutrients to plants.”

Mathematical Language and English Language Learners

As teachers plan for implementing mathematical events in linguistically diverse classrooms, it is imperative that they consider the various challenges and opportunities that confront ELLs. The possibility exists that ELLs have acquired mathematical vocabulary in their native language and lack a similar degree of proficiency in English. The complex and decontextualized nature of mathematical language compounds the challenges ELLs confront as they acquire or further develop English as a second language.

Students in general, ELLs in particular, are challenged with the multiple meanings of words. Misinterpretation of messages such as “*Odd* means ‘unusual or different,’” and then during mathematics encountering, “Circle the *odd* numbers” often results in confusion. Understanding polysemous terms (e.g., *odd*) requires that ELLs “discern the specialized meaning of common terms in a mathematical context” (Garrison & Mora, 1999). Research studies also suggest that the various linguistic challenges and the lack of automatic transfer between the first and second language require that teachers provide ELLs with high-quality, equitable opportunities for using mathematical language (Ron, 1999).

Implications for Instruction

It is crucial for early childhood educators to introduce and develop academic language, including mathematical language (Kirova, 2002). Researchers agree with Kang and Pham (1995) that students, regardless of their level of English-language proficiency, must be explicitly taught to use academic language. Researchers Davison and Pearce (1988, 1992) have reported improving the language function and mathematics performance of American Indian students after the participating teachers implemented systematic language activities, e.g., students creating word problems, recording in their mathematical journal, and writing descriptions/explanations of their problem-solving processes. Recent research-based strategies specific to Latino students include integrating language arts by incorporating the use of word walls, word webs, children’s literature, and cooperative learning (refer to Galván-Carlan & Rubin, 2003; Rubin & Galván-Carlan, 2004; Galván-Carlan & Rubin, 2005). Additional research-based practices include, but are not limited to, implementing a tactile-visual approach, e.g., using mathematical manipulatives and guiding students to describe these tactile experiences in writing (Davison, 2005), engaging in collaborative problem-solving and inquiry activities that explore word origins (Thomas & Collier, 1997), learning the roots of certain words (Rubenstein & Thompson, 2002), and using gestures, concrete objects, and pictures to clarify an idea (Gutierrez, 2002). Moschkovich (2002) cautions educators to focus on the resources (e.g., student’s first language, gestures, objects, mathematical representations) students use to communicate mathematically and to avoid emphasizing a deficit model that focuses solely on the challenges confronted by students, in particular ELLs. Spanish-dominant students can use true cognates, e.g., *volumen-volumen* and *sum-sumar* as a resource.

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Conclusion

The current emphasis on verbal and social communication highlights the significance of using research-based practices as tools to build on students’ intellectual capacity to effectively communicate their mathematical knowledge. Therefore, in addition to incorporating research-based practices in their teaching of mathematical language, educators need to focus on designing activities that build upon a variety of students’ resources in order to support academic success. Regardless of the students’ first language, it is imperative that educators support students’ legitimate resources in order to motivate them to build their competence, increase their confidence to communicate mathematically, and build a positive disposition toward mathematics. Hence, regardless of their level of English-language proficiency or mathematical knowledge, all students are competent and resourceful mathematical language learners.

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