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Using Two Languages When Learning Mathematics: How Can Research Help Us Understand Mathematics Learners Who Use Two Languages?

The number of students in the United States who are considered English learners is significant and growing. In 2002, approximately 4.5 million (9.3 percent) of U.S. students enrolled in K–12 public schools were labeled English learners (National Center for Education Statistics 2002).[i] Between 1979 and 2006, the number of school-aged children (ages 5–17) who spoke a language other than English at home more than doubled, from 3.8 to 10.8 million or from 9 to 20 percent of the population in this age range (Planty et al. 2008).[ii] As the number of English learners grows, so does the number of mathematics teachers needing to understand students who use two languages. This article summarizes research on how students who are bilingual or learning English use two languages and examines how this research is relevant to mathematics classrooms.

It is easy to notice that bilingual students sometimes use two languages. It is more difficult to know whether this practice might be significant to learning mathematics. What does research say about when, how, or why students switch from one language to another? How can research help us understand whether switching languages impacts or reflects mathematical reasoning?

Although research in mathematics education is beginning to consider students who are bilingual and/or learning English, research on this student population from fields outside of mathematics education also provides important information.[iii] This article also summarizes research from psycholinguistics and sociolinguistics on using two languages relevant to participation in mathematics classrooms.[iv]

Definitions

The labels *bilingual* and *English learner* are used ambiguously and have multiple meanings. The same students may be labeled bilingual, limited English proficiency (LEP), or English Language Learners (ELLs). These labels are not used in a consistent manner, and students who were once labeled bilingual might now be labeled English learners. Although these labels have been used interchangeably, they are not equivalent. Most important, the labels may not reflect an accurate assessment of an individual student's actual language proficiencies.[v] I use the label *bilingual* because this term emphasizes student competencies rather than deficiencies.

Research can clarify the meaning of the term *bilingual*. Meanings for *bilingualism* range from native-like fluency in two languages, to any use of two languages, to participation in a bilingual community. Many linguistics researchers view bilingualism not as an individual proficiency but as a social and cultural phenomenon. For example, Valdés-Fallis (1978) defines a bilingual speaker as "the product of a specific linguistic community that uses one of its languages for certain functions and the other for other functions or situations" (p. 4). Another common misunderstanding of bilingualism is the assumption that bilingual students are equally fluent in their two languages. Scholars studying bilingualism see "native-like control of two or more languages" as an unrealistic definition that does not reflect evidence that the majority of bilingual speakers are rarely equally fluent in both languages. Grosjean (1999) proposes a shift from using the terms *monolingual* and *bilingual* as labels for *individuals* to using these as labels for the endpoints on a continuum of *modes*. From this perspective, bilingual students use one language, the other language, or the two together as they move along a continuum from monolingual to bilingual *modes*.

Linguists refer to the practice of using two languages during one conversation or within one sentence as *code-switching*. Research has documented how code-switching has been stigmatized (Grosjean 1999), particularly in classrooms (Valdés-Fallis 1978), or considered as an unacceptable variety of language (Ramirez and Milk 1986). When a bilingual student inserts an English word or phrase into a Spanish conversation or vice versa, does this reflect some linguistic deficiency? Absolutely not. In fact, the opposite is true. Although code-switching has an improvised quality, it is a complex, rule governed, and systematic language practice reflecting a speaker's understanding of his or her community's linguistic norms (Zentella 1997).

Although the attitude that code-switching is a deficiency can be heard in admonitions such as "it's not good English" or "it's not good Spanish," interpreting code-switching as a deficiency is not a view supported by research. Overall, researchers agree that "code switching is not an ad hoc mixture but subject to formal constraints and that for some communities it is precisely the ability to switch that distinguishes fluent bilinguals" (Zentella 1981). Teachers, themselves, code-switch at times to communicate effectively (Khisty 1995; Zentella 1981). If we see bilingual students moving along a mode continuum, then code-switching is a normal language practice in the bilingual mode, and bilingual language competence is simply different from monolingual competence (Bialystok 2001; Cook 1997).

Using Two Languages during Computation

Bilingual speakers sometimes switch languages when carrying out arithmetic computations. Anecdotal evidence, self-reports (Kolers 1968), and interview data (Marsh and Maki 1976; McClain and Huang 1982; Tamamaki 1993) support the claim that adults who are bilingual have a preferred language for carrying out arithmetic computation, usually the language of arithmetic instruction. For example, Spanish is my first language, and I learned mathematics through the seventh grade in Spanish only. I carry out addition and multiplication of whole numbers in Spanish (either "in my head" or in a mumbled whisper).[vi]

Several psycholinguistic experiments explored response time for bilingual adults' performance on arithmetic operations (Marsh and Maki 1976; McClain and Huang 1982; Tamamaki 1993). In summary, and as suggested by other reviews of this research, all we can safely say at this time is that "retrieval times for arithmetic facts *may* be slower for bilinguals than monolinguals" (Bialystok 2001, p. 203), in particular when bilingual speakers are not using their preferred language or are asked to switch from one language to another. Could these reported differences in retrieval times be relevant to mathematics learners in K−12 classrooms?

First, these studies were conducted in experimental settings and with small samples of adults. Therefore, we cannot conclude that reported differences in response time would appear in classroom settings or among bilingual children or adolescents. Most important, the reported differences in calculation times were miniscule: Differences between monolingual and bilingual adults ranged from 0.2 seconds to 0.5 seconds (for average response times ranging between 2 and 3 seconds). Such differences seem negligible for interactions in classrooms. The differences in response time can be easily eliminated if bilingual speakers are permitted to use only one of their languages (McClain and Huang 1982). This last finding supports classroom practices that allow bilingual students to choose the language they use for arithmetic computation in the classroom.

Studies focusing on computation say little regarding language switching during conceptual mathematical reasoning. How might switching languages for arithmetic operations impact solving arithmetic word problems? Although there is little research to address this question, Qi (1998) provides a case study of a bilingual adult who switched to her first language for simple arithmetic computation while solving arithmetic word problems. The study concluded that language switching was swift, highly automatic, and facilitated rather than inhibited solving word problems in the second language. Overall, there is strong evidence suggesting that bilingualism does not impact mathematical reasoning. As one researcher summarized, "The most generous interpretation that is consistent with the data is that bilingualism has no effect on mathematical problem solving, providing that language proficiency is at least adequate for understanding the problem" (Bialystok 2001, p. 203).[vii]

Using Two Languages during Conversations in Mathematics Classrooms

Sociolinguistic research on code-switching among children can help us to understand bilingual learners in mathematics classrooms. When, how, or why do students code-switch? Sociolinguists conclude that young bilingual students (beyond age 5) speak as they are spoken to. The language ability and language choice of the person addressing a bilingual child are "recognized as the most significant variable to date in determining the child's language choice" (Zentella 1981, p. 110). We can assume that in mathematics classrooms children will also speak as they are spoken to, depending on the language ability and choice of the person addressing them. Sociolinguistic research on code-switching among adults shows that this practice occurs in response to multiple aspects of situations (such as the hearer, domain, topic, roles, etc.) that work in complex ways in conversation.[viii] Martin-Jones (1995) concludes, "It is impossible to compile a comprehensive inventory of the functions of code-switching since the number of possible functions is infinite" (p. 99).

A common misunderstanding about code-switching is that it is a reflection or consequence of a missing word in the speaker's lexicon. It may seem reasonable to conclude that saying a word in language A during an utterance in language B means that the speaker does not know or cannot retrieve that word in language B. This is not, in fact, the best explanation of code-switching. A consistent finding regarding code-switching that is relevant to bilingual mathematics learners is that code-switching is not a reflection of a low level of proficiency in a language or the inability to recall a word (Valdés-Fallis 1978). Because bilingual speakers use two languages in complex ways that depend on so many aspects of a situation, researchers in bilingualism caution us against using the speakers' code-switching to reach conclusions about their language proficiency, ability to recall a word, or knowledge of a particular technical term.

We should not assume that bilingual students switch into their first language only because they are missing mathematical vocabulary. Although some bilingual learners may sometimes use their first language in this way, code-switching can serve many functions. Bilingual students may code-switch for politeness, humor, and other functions that are not necessarily related to either vocabulary or mathematics. For example, inducements and jokes have been documented during brief code-switching episodes (Sanchez 1994). The type of mathematics problem and students' previous experience with mathematics instruction may influence which language a student uses. Some students may choose to use their first language when working alone or on arithmetic computation. After completing a computation, a bilingual student may or may not translate the answer to the other language, depending on who else is in the conversation. If bilingual students have experienced mathematics instruction in their first language, they may talk about that topic in their first language. If they have not had any mathematics instruction for a topic in their first language, they may talk about that topic primarily in their second language.

Research in mathematics education also tells us that we should not draw negative conclusions about a student's mathematical proficiency on the basis of code-switching. Instead, this practice can provide resources for communicating mathematically. For example, students have been documented code-switching as they describe a mathematical situation, explain a concept, justify an answer, or elaborate on an explanation (Moschkovich 2002, 2007). Analyses of conversations among bilingual Latinos have documented code-switching for elaboration, first expressing propositions in English and then giving expansions, additional information, or details in Spanish (Sanchez 1994). In general, because code-switching has been documented as a resource for elaborating on a point that is repeated, without repeating the initial utterances word for word, we can expect students to use their other language to elaborate, expand, and provide additional information during classroom conversations.

Conclusions

Psycholinguistic experiments, although limited in scope, support the claim that bilingual adults have a preferred language for arithmetic computation. These findings suggest that classroom instruction should allow bilingual students to choose the language they prefer for arithmetic computation. Empirical studies of code-switching do not support a view of this practice as a deficit in itself or as a sign of deficiency in mathematical reasoning. Sociolinguistic research provides a complex view of code-switching and suggests that rather than viewing code-switching as a deficiency, instruction for bilingual mathematics learners should consider how this practice serves as a resource for communicating mathematically. Information about students' previous instructional experiences in mathematics is crucial for understanding how bilingual learners communicate in mathematics classrooms. Classroom instruction should be informed by knowledge of students' experiences with mathematics instruction, language history, and educational background.

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REFERENCES

Adler, Jill. "A Language of Teaching Dilemmas: Unlocking the Complex Multilingual Secondary Mathematics Classroom." *For the Learning of Mathematics*, 18, no. 1 (1998): 24–33.

———. *Teaching Mathematics in Multilingual Classrooms*. Dordrecht, The Netherlands: Kluwer Academic Press, 2001.

Bialystok, Ellen. *Bilingualism in Development: Language, Literacy, and Cognition*. New York: Cambridge University Press, 2001.

Cook, Vivian. "The Consequences of Bilingualism for Cognitive Processing." In *Tutorials in Bilingualism*, edited by A. de Groot and J. Kroll, pp. 279–99. Mahwah, NJ: Erlbaum, 1997.

Grosjean, Francois. "Individual Bilingualism." In *Concise Encyclopedia of Educational Linguistics*, edited by Bernard Spolsky, pp. 284–90. London: Elsevier, 1999.

Khisty, Lena Licón. "Making Inequality: Issues of Language and Meanings in Mathematics Teaching with Hispanic Students." In *New Directions for Equity in Mathematics Education*, edited by Walter G. Secada, Elizabeth Fennema, and Lisa Byrd Adajian, pp. 279–97. Cambridge: Cambridge University Press, 1995.

Kolers, Paul A. "Bilingualism and Information Processing." *Scientific American* 218 (1968): 78–86.

Marsh, Linda G., and Ruth H. Maki. "Efficiency of Arithmetic Operations in Bilinguals as a Function of Language." *Memory & Cognition* 4 (1976): 459–64.

Martin-Jones, Marilyn. "Code-Switching in the Classroom: Two Decades of Research." In *One Speaker, Two Languages: Cross-Disciplinary Perspectives on Code-Switching*, edited by Lesley Milroy and Pieter Muysken, pp. 90–111. Cambridge: Cambridge University Press, 1995.

McClain, Lucinda, and Judy Y. Shih Huang. "Speed of Simple Arithmetic in Bilinguals." *Memory & Cognition* 10, no. 6 (1982): 591–96.

Moschkovich, Judit N. "Supporting the Participation of English Language Learners in Mathematical Discussions." *For the Learning of Mathematics* 19, no. 1 (1998): 11–19.

———. “A Situated and Sociocultural Perspective on Bilingual Mathematics Learners.” *Mathematical Thinking and Learning* 4, nos. 2 and 3 (2002): 189−212.

———. “Using Two Languages When Learning Mathematics.” *Educational Studies in Mathematics* 64 (2007): 121−44.

Planty, Michael, William Hussar, Thomas Snyder, Stephen Provasnik, Grace Kena, Rachel Dinkes, Angelina KewalRamani, and Jana Kemp. *The Condition of Education 2008* (NCES 2008-031). Washington, DC: National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education, 2008.

Qi, Donald S. “An Inquiry into Language-Switching in Second Language Composing Processes.” *Canadian Modern Language Review/La Revue canadienne des langues vivantes* 54, no. 3 (1998): 413−35.

Ramirez, Arnulfo G., and Robert D. Milk. “Notions of Grammaticality among Teachers of Bilingual Pupils.” *TESOL Quarterly* 20, no. 3 (1986): 495−513.

Sanchez, Rosaura. *Chicano Discourse: Socio-Historic Perspectives*. Houston, TX: Arte Público Press, 1994.

Setati, Mamokgheti. “Code-Switching and Mathematical Meaning in a Senior Primary Class of Second Language Learners.” *For the Learning of Mathematics* 18, no. 1 (1998): 34−40.

Setati, Mamokgheti, and Jill Adler. “Between Languages and Discourses: Code Switching Practices in Primary Classrooms in South Africa.” *Educational Studies in Mathematics* 43 (2001): 243−69.

Tamamaki, Kinko. “Language Dominance in Bilinguals’ Arithmetic Operations according to Their Language Use.” *Language Learning* 43, no. 2 (1993): 239−62.

Valdés-Fallis, Guadalupe. “Code Switching and the Classroom Teacher.” *Language in Education: Theory and Practice*. Vol. 4. Wellington, VA: Center for Applied Linguistics, 1978.

Zentella, Ana Celia. “Tá Bien, You Could Answer Me En Cualquier Idioma: Puerto Rican Codeswitching in Bilingual Classrooms.” In *Latino Language and Communicative Behavior*, edited by Richard P. Durán, pp. 109−31. Norwood, NJ: Ablex, 1981.

———. *Growing up Bilingual: Puerto Rican Children in New York*. Malden, MA: Blackwell Publishing, 1997.

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i. In some states, this percentage was higher. For example, in 2000–2001, about 25 percent of the student population in California was reported as English learners (Tafoya 2002).

ii. The largest percentage of these children speak Spanish at home. In 2006, about 72 percent of school-age children who spoke a language other than English at home spoke Spanish (Planty et al. 2008).

iii. Elsewhere (Moschkovich 1998, 2002, 2007) I provide extended examples of discussions between bilingual students to illustrate how bilingual learners participate in mathematical conversations in classrooms.

iv. I use examples from research with Spanish-speaking bilingual learners to describe bilingualism and common language practices among bilingual mathematics learners principally because my own research focuses on this student population and because the largest population of K−12 students in the United States who are bilingual or speak another language at home are Spanish speakers (Planty et al. 2008). However, the perspective on language and bilingualism provided here is not specific to any one language and is relevant to students in U.S. classrooms who speak other languages, such Haitian Creole or Chinese, as well as to students in multilingual classrooms, for example, in South Africa (Adler 1998, 2001; Setati 1998; Setati and Adler 2001).

v. It is important to note that for the largest population of students reported as speaking a language other than English at home (Latinos/as), bilingual students are only a subset of the Latina/o student population, since many Latina/o students are monolingual English speakers.

vi. Some bilingual speakers may also perform different types of calculations in different languages, depending on the language of instruction for different topics (arithmetic, algebra, or calculus). For example, I carry out arithmetic calculations in Spanish, algebra in either language, and calculus in English.

vii. A crucial concern for instruction, then, is to ensure “that language proficiency is at least adequate for understanding the problem” and/or that the language of instruction and assessment includes access to learners’ first language, so that all students, including those who are learning English, have an opportunity to understand the text of the word problem and thus be successful in solving word problems.

viii. Because this article focuses on bilingual children learning mathematics, I do not describe research documenting teachers’ code-switching in classrooms. For examples, see Khisty (1995), Setati (1998), Setati and Adler (2001), Valdés-Fallis (1978), and Zentella (1981).