What Mathematics Teachers Need to Know about Culture and Language

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For some time now, school improvement efforts have been inextricably linked to the steady demographic shifts of our nation’s student populations. With more and more students speaking home languages other than English and representing cultural traditions outside those of mainstream America, teachers now need more and better cultural and linguistic knowledge in order to teach effectively (Wong-Fillmore & Snow, 2000). In actuality, American society has long been diverse, but it is only in recent decades that large numbers of educators have recognized that education guided solely by Western European-American values and experiences (representing the dominant culture) is inappropriate or ineffective for many students.

The aim of this chapter is to discuss what mathematics teachers need to know about cultural and language practices that are germane to students’ learning mathematics and to the design of mathematics instruction. Students whose cultural communities represent approaches to teaching, learning, and using language that differ from those of the mainstream demand relevant knowledge and understanding from teachers. In our exploration of cultural practices, we focus on research and practice within indigenous communities throughout the United States and the Pacific region. In our exploration of language, we focus on English learners, for whom successful instruction also depends upon specialized teacher knowledge and understanding.

At this juncture, four points must be emphasized:

1. Indigenous students who speak English are also likely to be bilingual or to speak a variety of English that is not the same as that used in school.
2. English learners most often come from families whose cultural practices are different from those of the mainstream.

3. Language and culture are of a piece, in that language is a cultural resource and creation that reflects a culture's values, experience, and goals and is used to transmit them across generations. As Nieto (1999) says, "[T]he language, language variety, or dialect one speaks is culture made manifest" (p. 60). This is equally the case in the classroom, where the cultural practices and language (and a particular dialect of it) reign.

4. Perhaps the most powerful language differences lie at the intersection of language and culture. They have to do with the sociocultural aspects of language use—how children and adults are expected to participate in conversation, argument, discussion, story telling, explanation, or recounting of experience (Gee, 1996; Heath, 1983, 1986).

Many of the issues highlighted by a discussion of mathematics instruction and learning are in large part applicable to teaching in general. But mathematics is of special interest because it is so widely thought to be “free” of language and culture. In fact, because mathematics is a multisemiotic system, mathematical practices are highly dependent on natural language as well as other semiotic systems (Abedi, 2003; O’Halloran, 2005; Radford, Bardini, & Sabena, 2007; Sáenz-Ludlow & Presmeg, 2006; Schleppegrell, 2007); and ways of thinking mathematically are, like other ways of thinking, culturally situated (Lave, 1988; Lave & Wenger, 1991; Saxe, 1991; Solano-Flores & Nelson-Barber, 2001).

Meeting these demands for cultural and linguistic knowledge can be quite a challenge for teachers, given the generally inadequate preparation provided by teacher education programs for discerning and building upon linguistic and cultural differences in ways that result in enriched schooling experiences for students from routinely underserved groups (Nelson-Barber, 1999).

Teacher Knowledge

Knowledge about students' cultural and linguistic backgrounds may contribute to teachers' ability to establish the kinds of relationships with students that motivate them to succeed (cf., Nieto, 1996). However, deeper knowledge about the linguistic and cultural practices in students' communities is essential if teachers are to make connections between the content they are trying to teach and what their students already know (Trumbull, Nelson-Barber, & Mitchell, 2002). If, as cultural psychologists contend, the mind itself is forged in a cultural context (cf., Cole, 2002; Kozulin, 1998), to understand students' ways of knowing and learning, teachers need knowledge of the cultural practices within students' communities—especially practices related to communicating, interacting with adults and peers in groups, and constructing knowledge. General recognition that student cultural and linguistic backgrounds matter and that knowledge about them should be sought is relevant to the different kinds of classes that a teacher may have—relatively homogeneous (e.g., a reservation school), mixed (e.g., Latino/a, African American, European American), along with classes that are composed of students from numerous ethnolinguistic groups (e.g., “United Nations”), which are now evident in rural as well as large metropolitan areas. In the absence of such teacher knowledge, classrooms can be places where teachers' assumptions about students' experiences and approaches to learning (Spindler & Spindler, 2000) may combine with subtle, yet damaging, attitudes toward difference, which can serve to widen the distance between teacher and student and between student and school—reducing student engagement and learning (e.g., Nelson-Barber, 1999; Osterman, 2000; Valenzuela, 1999).

The need to communicate across differences in cultural and language practices is an everyday fact of life in today's bilingual and multilingual classrooms. Studies that describe how teachers and students in such classrooms communicate mathematical ideas reveal the complexity of these learning environments (Adler, 1998, 2001; Khisty, 1995, 2001; Khisty & Chval, 2002; Moschkovich, 1999a, 2000, 2002a; Setati, 1998; Setati & Adler, 2001). Teachers need to develop the capacity to see, hear, and build on students' own and varying mathematical ideas, some of which may be rooted in local knowledge systems and community practices (Moll & Gonzalez, 2004). They need to understand that students may use different national languages and dialects to express specialized, discipline-based knowledge, such as mathematics, differently, but that there are also differences across formal and informal language registers.2

It is equally important for teachers to be knowledgeable about the home and community practices that are integral to the multiple and hybrid styles of communication that children use in classrooms (Gutiérrez, Baquedano-López, & Alvarez, 2001). Cultural differences in communication style will be apparent across all content areas of the curriculum. Students from some communities, for example various Asian (Ho, 1994; Ryu, 2004) or Latino/a (Greenfield, Quiroz, & Raeff, 2000) groups, may have been socialized to listen respectfully to adults. In contrast, students from other communities, in particular their dominant culture peers, may have been socialized to interact with adults more directly—even to question them (Greenfield et al., 2000; Snow, 1983). Students socialized in these very different ways can be expected to respond quite differently to classroom demands to participate. In other words, teachers need to know something about students' home, community, social, and cultural values and practices and how these may influence classroom interactions across all content areas. Even recognizing that there are such differences and that they are not deficits is an important step for a teacher who is teaching students from a cultural or linguistic community different from her own.

In the following sections, we discuss culture and language separately for the purpose of organizing the chapter and providing grounded examples in which the focus shifts to either language or culture. Nevertheless, readers should bear
in mind that a shifting focus does not imply that these aspects of human activity can truly be understood independently of each other.

A Cultural Affirmation Approach to Difference

As a way to frame the many connections among language, culture, and mathematics learning/teaching, we use Brenner's (1998) three-dimensional framework, which reflects a "cultural affirmation approach." That is to say, practices and approaches to learning that are different from those of the dominant culture (reflected in schooling practices) are affirmed rather than denied. This framework identifies three areas central to ensuring that curricula and instructional practice are culturally relevant for students: cultural content, social organization, and cognitive resources.

As Brenner sees it, examining materials and instructional techniques for their cultural content can reveal the extent to which mathematical activities utilized in instruction relate to mathematical activities operating in local community practices, no matter what communities students come from. For instance, in an agricultural setting, mathematical concepts and operations can be taught as they pertain to crop planning, rotation, harvesting, and marketing. Where fishing and navigation are prominent, instruction can capitalize on community-based practices of predicting and measuring tides, calculating navigational routes, estimating the food yield of a catch, and the like.

Similarly, ensuring that classroom social organization takes into account a variety of possible roles, responsibilities, and communication styles and includes multiple and hybrid repertoires of practice (Gutiérrez & Rogoff, 2003) will more likely support comfortable and productive student participation. For example, one recent study in a second-grade classroom where immigrant Latino/a students predominated showed that when students were allowed to work cooperatively to learn "math facts," they performed better than when they were required to work independently on the same material (Rothstein-Fisch, Trumbull, Isaac, Daley, & Pérez, 2003). In a similar classroom, with immigrant Latino/a students, Isaac (1999) observed tensions within and between children when their teacher forced them to stop helping one another and to compete. Additional work among indigenous communities in Alaska (e.g., Ilutsik, 1994; Nelson-Barber & Dull, 1998) and in Micronesia (Nelson-Barber, 2001; Nelson-Barber, Trumbull, & Wenn, 2000) documented tendencies of students to gravitate toward cooperative rather than competitive ways of interacting (see also McDermott & Varenne, 2006). These studies are part of a body of research that seeks to understand the kinds of resources students bring from home and ways in which they apply to school relationships across cultures.

Classrooms that make use of the cognitive resources students bring from previous instruction and from home—a variety of ways of thinking used in their communities to solve problems—make the most of students' existing knowledge and lived experiences (Moll & Gonzalez, 2004). Language is one such cognitive resource, as are local systems for collecting and interpreting data (e.g., related to environmental changes, weather patterns), family systems for tracking the completion of work, and specialized local maps. Teachers' ability to recognize and appreciate students' particular cognitive resources ultimately has a bearing on how they interpret student talk and activity in the classroom. Awareness of other ways of thinking, constructing knowledge, and problem solving can yield insights into the cultural nature of "usual" school-based practices. As Bruner (1996) observed, "School curricula and classroom climates always reflect inarticulate cultural values as well as explicit plans..." (p. 27). The school can never be considered as culturally "free standing." (pp. 27–28).

A Caveat About Generalizations and Assumptions

At this point, we would like to share a few words of caution. First, tapping into students' content knowledge and problem-solving strategies does not translate to automatic understanding of students' epistemologies or the underlying socio-cultural practices (e.g., values, beliefs, experiences acquired as a member of a given community) that influence how students construct knowledge (Solano-Flores & Nelson-Barber, 2001). Second, we should not assume that communication styles and home cultural practices are homogeneous in any community, dominant or nondominant. Nasir and Cobb (2002) argue that "equity does not merely involve helping students reach higher standards set by the mainstream but instead is a matter of understanding diversity as a relation between the community of practice established in the math classroom and the other communities of practice of which students are a part" (p. 97). Gutiérrez, Baquedano-Lopez, and Alvarez (2001) describe language practices as "hybrid," meaning that they are based on more than one language or dialect. Gutiérrez and Rogoff (2003) caution us against ascribing cultural practices to individuals and instead propose we consider the repertoires of practice that any one individual has had access to. We cannot assume that any cultural group has "cultural uniformity or a set of harmonious and homogeneous shared practices" (González, 1995).

González (1995) decrues perspectives that "have relegated notions of culture to observable surface markers of folklore, assuming that all members of a particular group share a normative, bounded, and integrated view of their culture" and suggests that "approaches to culture that take into account multiple perspectives can reorient educators to consider the everyday experiences of their students" (González, 1995, p. 237). Still, Brenner's three-part framework can be used as a broad guide for designing curricula, instruction, and assessments. It leads teachers to consider the complexity in what constitutes comfortable and productive participation for learners, as well as the multiple communication practices that students have experienced, both at home and in school.
What Do Mathematics Teachers Need to Know to Address Cultural Content, Social Organization, and Cognitive Resources?

Cultural Content

Connecting school mathematics with children's own experiences and intuitive knowledge has been an important theme in efforts to improve formal mathematics education (Lipka, Webster, Yanez, 2005; Trumbull, Nelson-Barber & Mitchell, 2002, among others). With today's call for higher standards of effectiveness in the classroom and greater teacher accountability, practitioners are finding that they need to become knowledgeable about their students' personal experiences, particularly as the research continues to demonstrate that factors of context and culture are powerful contributors to the ways in which students make sense of schooling (e.g., Barnhardt & Kawagley, 2005; Delpit, 1995; Ladson-Billings, 1994; Nelson-Barber, 2006; Gutiérrez & Rogoff, 2003; Solano-Flores & Nelson-Barber, 2001, Trumbull, Greenfield & Quiroz, 2004).

For example, though indigenous groups are distinctive from another (i.e., consider the diversity of ecosystems among the Hopi of northeastern Arizona in comparison with the Makah of northwestern Washington state), it is a widespread practice among members of these groups to maintain extensive knowledge of the natural environment and deep spiritual connections to their land base. As a result, many indigenous students experience culturally embedded, community-based education from an early age. Elders and other community members educate their youth about the requisite cognitive tools that suit local purposes, such as the processing of plants and herbs for medicinal purposes (pharmacology), a lifestyle that successfully manages wildlife and habitats (conservation biology), or about how to rely on star formations to track the migratory patterns of buffalo or hunt on the tundra (celestial navigation). Using conceptions of environmental phenomena embodied in local ways of thinking, reasoning, and expression, community educators convey specialized ethnomathematics and ethnoscience knowledge that is implicit in the activities they carry out for practical purposes.

It is also the case that many tribal groups socialize their children to pursue balanced and harmonious lives—what the Diné (Navajo) characterize as achieving a state of hózhó. Benally (1988) writes, "The individual is taught the interrelationship and interdependence of all things and how we must harmonize with them to maintain balance and harmony" in our lives (p. 10). According to Benally (1988), this integrated reality enfolds Navajo learners as they pursue a state of hózhó. All knowledge is viewed with respect to its ability to draw one closer to this spirit of harmony. By contrast, "western organization of knowledge, with its fragmentation...and lack of connectedness, does not promote hózhó" (p. 12). Here, it is evident that one cannot consider cultural "content" without also considering the epistemological framework that addresses the nature of "knowledge." What is knowledge? What is its purpose?

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American Indian philosopher Vine Deloria, Jr. (1992) further defines this epistemological perspective when he explains that indigenous peoples understand new information and experience in terms of their full tapestry of continuous experience and contextualized knowledge. Rather than matching generalizations with new phenomena (a "Western" approach), Native people match their more specific body of information with the immediate event or experience. In other words, from an indigenous perspective: (1) the observer is not separate from the observed and (2) broad generalizations cannot be abstracted from experience and then used to explain new experiences. Aleut educator, Larry Merculieff (2004), explains that "separating the 'what' from the 'how' results in use of information out of context... Cultural wisdom passed on to new generations can be understood and applied only to the degree the individual integrates this wisdom into everyday life and living" (p. 2). This distinctive approach to education is akin to Valenzuela’s (1999) notion of “educación,” which she characterizes as “a conceptually broader term than its English language cognate. It refers to the family's role of inculcating in children a sense of moral, social, and personal responsibility and serves as the foundation for all other learning” (p. 23).

Thus, an indigenous approach to “understanding” includes essential ethical and historical dimensions that situate knowledge in a context. A more complete approach to instruction—one relevant to many indigenous students—would include transformative dimensions, promoting an inquiring stance toward the content itself. Questions are needed that arise from taking ethical and historical standpoint, such as: What knowledge is important to the survival of our society, our earth? To what use will knowledge be put? What might be the effects of using knowledge in this way? Such questions need to be addressed in schools that serve indigenous communities. Moreover, “progress” may be conceived of more in spiritual and ethical terms than in terms of the growth of knowledge per se. As much as these principles affirm local values and epistemologies, they also bring forth elements that the “mainstream” could learn from and adopt.

Cognitive Resources and Social Organization

The ways of knowing acquired by children who populate today’s diverse classrooms often represent values, beliefs, and perspectives specific to their cultural communities, and these resources, which are largely expressed in their preferences for thinking, observing, and (inter)acting, have great influence over their learning as well as how they approach schooling. Indigenous students whose life ways emphasize knowledge of the natural environment and whose groups maintain spiritual connections to their land base experience culturally embedded, community-based education from an early age. Thus it is quite useful to examine ways in which indigenous contextual concepts and cultural heritage practices influence how these students learn about the mathematics they encounter in school (Nelson-Barber, 2006).
Vygotskyan theorists posit that cultures create meaning from experience in different ways (cf., Vygotsky, 1978; Wertsch, Del Rio, & Alvarez, 1995). Key factors that influence students' ways of learning and thus interact with the nature of schooling (Cole, 2002) include:

1. Their sociocultural setting (cf., Berger & Luckman, 1966; Whorf, 1956).
2. Their community's relationship with place and forms of place-based learning (Basso, 1996; Gladwin, 1970; Hutchins, 1996; Kanaiapuni, 2004).
3. Patterns of interaction between individuals in the community (Au, 1980; Giolli, 1972; Labov, 1972; Nelson-Barber, 1985), and
4. The manner in which all of these factors combine to structure learners' engagement in ethnomathematical heritage activities (cf., Lipka & Adams, 2004; Nelson-Barber, Trumbull, & Wenn, 2000) and eventually in formal education (Cazden, John, & Hymes, 1972; Lipka, 1998; Nelson-Barber, 2001, 2006).

Sociocultural setting and sense of physical place are two distinct, yet experientially interwoven, factors that together influence all knowledge construction and interactions within the community. The significance of place for many indigenous communities is deep and abiding. Research in place-based education also points to the meaning of place and its relevance to schooling across a range of cultural and geographic contexts (cf., Miller & Hahn, 1997; Rural School and Community Trust, 2000; Smith, 2002; see also, Cajete, 2001). Because place- and culture-based education derive from the particular local context of a cultural group or nation, one must understand the teaching and learning styles of such a group in order to orchestrate instruction and make accurate judgments about student learning and conceptual understanding (Delpech, 1995; Lipka, 1998; Steele, 1991).

Borba (1990) observes that the practices developed by different groups are likely to be more efficient for solving problems related to their own surroundings than are academic mathematical practices, because the solutions are tailored to the particular obstacles encountered by those groups. For example, the nature of a map that will be useful to a traveler going by foot through Arctic territory, in which physical features (including trail contour and visibility) change frequently because of weather effects, will be quite different from one useful to a traveler going by car on highways through the Midwest. The mapmaker in the first case will need to select environmental benchmarks that resist destruction or disguise by weather. As Greenfield (1997) points out, understanding this tailoring of information for real-world problem solving together with the epistemologies intrinsic to given cultures—the way groups construct knowledge and view the world—can help teachers avoid misjudgments about group member capabilities (cf., Baugh, 2000; Kopriva & Sexton, 1999; Meier, 2008). Cognitive resources, quite naturally, are likely to look different depending upon the communities of practice in which they originate.

Beyond a Single, "Western" Notion of Mathematical Knowing and Doing

So, if we understand that all cultural groups generate mathematical knowledge, we also understand that this knowledge may appear and be demonstrated very differently from one group to another. People from all communities see patterns in the natural world, create categories, and develop classification systems to organize daily life in these terms. For all groups, mathematical ideas are concerned with space, number, and logical relationships and with systems for organizing these elements (e.g., Bishop, 1988). However, the ways in which any community handles mathematical ideas will be both constrained and afforded by local needs, such as the need to organize social and kinship systems or devise effective approaches to navigation.

Moreover, these ethnomathematical constellations of ideas and systems of representing knowledge cannot be compared along any single linear, developmental scale, contrary to the way "western" texts on mathematics, for instance, have tended to represent "progress" in mathematical thinking (Ascher, 1991). This "Western" approach is situated in a worldview that posits discrete entities, quantities, and states. Natural phenomena are often analyzed out of context, "objectified"; and scientific "facts" are thought to be value-free, and determined through rigorous observation or experimentation. From this perspective, societies and their cognitive systems, such as science and mathematics, are viewed as moving inexorably toward more complex ("advanced" or "better") states. There is an expectation that what is to come will be better than what went before. Time is sequential and linear.

These taken-for-granted, features of Western thought run counter to the ways of knowing of many Indian cultures, where interrelationships, flux, observation, and evaluation in context, and a more circular view of time prevail (cf., Johnston, 2002, 2003; Nelson-Barber, LaFrance, Trumbull, & Aburto, 2005; Sapir, 1921; Whorf, 1956; Witherspoon, 1977). From a Navajo perspective, "the focus is on process, change is ever-present; interrelationship and motion are of primary significance. These incorporate and subsume space and time" (Ascher, 1991, p. 129). Space is not conceived of as separate from time and motion. Ascher (1991) offers the example of an Inuit (living in Alaska) who travel great distances across a continually changing landscape of snow and ice, and who may find it more useful to note significant, unchanging aspects of a landscape (a hill, a ridge along a river, the configuration of a coastline) than to establish distance measures in standardized units. Community practices may tend toward valuing multiple perspectives rather than an ability to use specific units of measurement. Thus, when spatial boundaries are not independent of the processes of which they are a part, segmenting space in an "arbitrary and static way without accounting for flux over time is senseless" (Ascher, 1991, p. 129). A teacher who has been exposed to this very different perspective is more likely to understand the thinking of a student from such a community—or at least to stop short of judging this student's ways of thinking as defective.
need to learn how to value and capitalize on student’s particular linguistic skills and at the same time explicitly model and teach the discourse styles expected in most classrooms, where there are rules about who can talk when, about what, and in what manner, as well as predictable communication routines that get established early in the school year (Morine-Derschimer, 2006, p. 129). The research leaves little doubt that the ways of organizing discourse can either include or exclude students from participating, particularly young children or those otherwise not accustomed to classroom norms of communicating. Discourse mediates students’ learning, and “[t]eacher management of verbal interaction processes can strongly influence who has an opportunity to learn, as well as what disciplinary knowledge and what social values are available to be learned” (Morine-Derschimer, 2006, p. 132).

The practice of incorporating students’ own ways of using language into the classroom is now recognized as one aspect of the success of many elementary schools serving Latino/a students (for example, in Los Angeles, as described in Greenfeld, Quiroz, & Raeff, 2000; Isaac, 1999; Rothstein-Fisch et al., 2003; Trumbull, Greenfeld, & Quiroz, 2004). What are some of these ways of using language that instruction should build on? What are common language practices among students from nondominant language communities? We will use the case of bilingual mathematics learners to describe some of these practices in more detail.

What Do Mathematics Teachers Need to Know about Language and Bilingual Mathematics Learners?

In this section, we use examples from research with Spanish-speaking bilingual learners to describe what mathematics teachers need to know about bilingualism and about common language practices among bilingual mathematics learners (Moschkovich, 2007a, 2007b). Many conversations about “language” are clouded by the fact that there are multiple meanings for terms such as language and bilingual, meanings that sometimes are strongly tied to fundamental assumptions and attitudes about language and thinking. We will clarify our use of these terms. First, we distinguish between national languages (such as Spanish or Haitian Creole) and social languages used in particular settings (such as mathematics classrooms). We assume that understanding utterances and texts involves generating and negotiating meanings and interpretations. We also assume that these meanings and interpretations are situated in practices and communities, not individuals. And lastly, we assume that any speaker’s competence is multifaceted: How a person uses language will depend on what is understood to be appropriate in a given social setting, and as such, linguistic knowledge is situated “not in the individual psyche but in a group’s collective linguistic norms” (Hakuta & McLaughlin, 1996, p. 22).
Bilingualism

Definitions of bilingualism range from nativelike fluency in two languages, to alternating use of two languages (De Avila & Duncan, 1981), to belonging to a bilingual community (Valdés-Fallis, 1978). We ground ourselves in a definition that characterizes bilingualism as not only an individual but also a social and cultural phenomenon involving participation in language practices and communities: "...the product of a specific linguistic community that uses one of its languages for certain functions and the other for other functions or situations" (Valdés-Fallis, 1978, p. 4).

"Bilingual" refers to a wide range of proficiencies in two languages, and modes (listening, writing, speaking, and reading). Current scholars studying bilingualism see "nativelike control of two or more languages" as an unrealistic definition that does not reflect evidence that the majority of bilinguals are rarely equally fluent in both languages: "Bilinguals acquire and use their languages for different purposes, in different domains of life, with different people. It is precisely because the needs and uses of the languages are usually quite different that bilinguals rarely develop equal fluency in their languages" (Grosjean, 1999, p. 285).

Grosjean proposes we 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. Bilinguals make use of one language, the other language, or the two together as they move along a continuum from monolingual to bilingual modes:

Researchers are now starting to view the bilingual not so much as the sum of two (or more) complete or incomplete monolinguals but rather as a specific and fully competent speaker-hearer who has developed a communicative competence that is equal, but different in nature, to that of the monolingual. (Grosjean, 1999, p. 285)

Whereas being bilingual in some languages and settings is a sign of education and cultural advantage, bilingualism in other languages or in other settings can be associated with poverty, lack of education, or imagined cultural disadvantages (De Avila & Duncan, 1981). For example, Latino/a bilinguals in the United States have a particular history as part of a language minority. Some bilingual Latinos/as came to the United States as immigrants, others are the descendants of immigrants, and still others never immigrated or emigrated anywhere but live in regions that were originally part of Mexico and later became part of the United States. In the United States, bilingualism is not always considered an asset. In particular, Spanish is not considered a high-status second language. Bilingual Latino/a learners in the United States, instead of being viewed as having additional language skills, have often been described in terms of deficiency models (Garcia & Gonzalez, 1995). No doubt in part because of this devaluing of Spanish as a heritage language, there is a pattern of language loss from one generation to another (Tse, 2001).

Common Language Practices among Bilingual Mathematics Learners

Two common language practices documented among bilingual learners are using two languages when carrying out arithmetic computation alone and during a conversation with another person. Bilingual mathematics learners sometimes use two languages during arithmetic computation and sometimes code-switch (alternate between two languages such as Spanish and English) during one conversation—or even within a single sentence (Gumperz, 1973). What can research tell mathematics teachers about these two practices?

Although there are no available studies documenting language switching during computation among children or adolescents, several experimental (and often cited) studies with adults concluded that adult bilinguals have a preferred language for carrying out simple arithmetic computation (usually the language they experienced during arithmetic instruction). For example, two studies conducted with adult U.S. Spanish speakers (Marsh & Maki, 1976; McLain & Huang, 1982) found that adult bilinguals performed arithmetic operations more rapidly in their preferred language than in their nonpreferred language. These studies suggested that adult bilinguals may be "slower" when using their nonpreferred language. However, the reported differences in response times were infinitesimal (about 0.2 seconds for average response times ranging between 2 and 3 seconds), and the small difference in response time disappeared if there was no switch from one language to another during the experiment. Even though these results apply to adults, one finding by McLain and Huang (1982) may be relevant to mathematics classrooms. This study showed that if bilingual adults were required to use only one of their languages, the "preferred language advantage" was eliminated. On the one hand, this finding suggests that classroom practices that allow bilingual students to choose the language they use for arithmetic computation in the classroom, rather than requiring them to change languages, may be beneficial to bilingual mathematics learners because such changes may impact response time. On the other hand, we need to remember that any reported differences in response times were minimal.

Because these studies focused on computation, they say little regarding language practices during more conceptual mathematical activity. What might be the role of translating arithmetic computation from one language to another while solving word problems? Unfortunately, there is little research available to answer this question. One possible source is a case study of a bilingual adult when solving arithmetic word problems (Qi, 1998). The case study described how she switched to her first language for simple arithmetic computation while solving word problems. The study concluded that while solving word problems, this adult's switches were swift and highly automatic and that language switching facilitated rather than inhibited solving word problems in the second language. There seems to be strong evidence suggesting that switching languages does not affect the quality of conceptual thinking (Cumming 1989, 1990 as cited in Qi, 1998).
What Mathematics Teachers Need to Know about Culture and Language (Zentella, 1997). As such, it should be distinguished from the language mixing that may take place early in the development of a new language (Bialystok, 2001). Researchers have concluded 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 in order to communicate effectively (Khisty, 1995, 2001; Zentella, 1981).

How, when, and why do children code switch? Sociolinguists have concluded that, overall, young bilinguals (beyond age 5) speak as they are spoken to. A bilingual child's choice of language seems to be most dependent on the person addressing him or her. 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).

The consistent conclusion that code switching is not a reflection of a low level of proficiency in a language or the inability to recall a word (Genesee, 2002; Valdés-Fellis, 1979) is relevant to bilingual mathematics learners. It may seem reasonable to conclude that uttering a word in language A in the middle of an utterance in language B means that the speaker does not know or cannot retrieve that word in language B. But teachers need to recognize that this is not, in fact, the best explanation of code switching. Because bilinguals use two languages depending on the interlocutor, domain, topic, role, and function, researchers in bilingualism caution us against using someone's code switching to make conclusions about their language proficiency, ability to recall a word, or knowledge of a particular technical term. Likewise, it is not warranted to draw simple conclusions about a student's mathematical proficiency on the basis of his or her code switching.

In summary, teachers need to be familiar with the findings from current research on bilingual learners. Nativelike control of two or more languages is an unrealistic definition of bilingualism that does not reflect evidence that the majority of bilinguals are rarely equally fluent in both languages. Teachers need to know and build on the fluencies their students bring rather than comparing bilinguals to monolinguals or focus on how bilingual students miss the mark in comparison to monolinguals. Because bilinguals have a wide range of proficiencies in two languages, teachers should not expect mathematics students to know mathematical terms in a first or second language unless they have had mathematics instruction in that language. Bilinguals have a wide range of proficiencies in modes (listening, writing, speaking, and reading) in their two languages. Teachers should not assume that proficiency in one mode implies proficiency in another mode and should provide mathematics assessment and instruction across all modes. Switching languages is not a sign of a deficiency. In fact, this skill is a complex cognitive and linguistic resource. Teachers should not imagine that switching languages is related to mathematical thinking or understanding in any simple way.
What Do Mathematics Teachers Need To Know about Mathematical Discourse?

Teachers need to not only understand bilingualism and the common language practices bilingual students are likely to engage in, they also need to understand what is entailed in communicating mathematically, also known as participating in “mathematical discourse.” Current research in mathematics education describes how, as students are learning mathematics, they are also learning to participate in mathematical discourse (Cobb, Wood, & Yackel 1993; Forman, 1996; Moschkovich, 2002a, 2007c). The term discourse is another example of a term with multiple meanings. Some use the word discourse to refer to any unit of language longer than a sentence. Gee (1996) distinguishes between discourse and Discourse. In keeping with this distinction, we will use the term Discourses. Gee’s definition of Discourses highlights how these are not just sequential speech or writing:

A Discourse is a socially accepted association among ways of using language, other symbolic expressions, and “artifacts,” of thinking, feeling, believing, valuing and acting that can be used to identify oneself as a member of a socially meaningful group or “social network,” or to signal (that one is playing) a socially meaningful role. (p. 131)

As a start, mathematical Discourse involves the mathematics register. Halliday (1978) defines register as:

...a set of meanings that is appropriate to a particular function of language, together with the words and structures which express these meanings. We can refer to the “mathematics register,” in the sense of the meanings that belong to the language of mathematics (the mathematical use of natural language, that is: not mathematics itself), and that a language must express [itself] if it is being used for mathematical purposes. (p. 195)

Researchers have described learning to communicate mathematically as, in part, sorting out differences in meanings of many terms and phrases that are used both in mathematics and everyday settings (Khisty, 1995; Moschkovich, 1996, 2002a, 2007c; Pimm, 1987). Since there are multiple meanings for the same term or phrase, as students learn mathematics they are learning to use these multiple meanings appropriately. Examples of multiple meanings are the meanings for the word set and the phrase any number, which, in a mathematics classroom, means “all numbers” (Pimm, 1987). But the mathematics register does not simply imply the meaning of single words or phrases, it also involves relational meanings between pairs of terms. Walkerdine (1988) contrasts the way that in school the opposite of “more” is assumed to be “less.” In contrast, she documented how in British home settings, young children usually experienced the opposite of “more” as “no more.” For example, if a child asked for more paper, she was likely to hear the response “there is no more paper” rather than a response using the term less (Walkerdine, 1988). Walkerdine thus documented how at home children paired up “more” with “no more” while at school the expectation was that the opposite of “more” would be “less.”

What are mathematical Discourse practices? In general, students communicate mathematically by making conjectures, presenting explanations, constructing arguments about mathematical objects, with mathematical content, and toward a mathematical point (Brenner, 1994). Participating in classroom mathematical Discourse practices involves much more than the use of technical language. We should not imagine that classroom discussions involve one single set of discourse practices that are (or are not) mathematical. In fact, we might imagine the classroom as a place where multiple Discourse practices meet. Mathematical Discourse practices vary across different communities; for example, between research mathematicians and statisticians, elementary and secondary school teachers, or traditional and reform-oriented classrooms. Mathematical arguments can be presented for different purposes such as convincing, summarizing, or explaining. Mathematical Discourse practices also involve different genres such as algebraic proofs, geometric proofs, school algebra word problems, and presentations at conferences.

In general, particular modes of argument, such as precision, brevity, and logical coherence, are valued (Forman, 1996). Abstraction, generalizing, and searching for certainty are also highly valued practices in mathematical communities. The value of generalizing is reflected in common mathematical statements, such as “the angles of any triangle add up to 180 degrees,” “parallel lines never meet,” or “a + b will always equal b + a.” Making claims is another important mathematical Discourse practice. What makes a claim mathematical is, in part, the attention paid to describing in detail when the claim applies and when it does not. Mathematical claims apply only to a precisely and explicitly defined set of situations as in the statement “multiplication makes a number bigger, except when multiplying by zero, one, or a number smaller than one.” Many times claims are also tied to mathematical representations such as graphs, tables, or diagrams. Although less often considered, imagining is also a valued mathematical practice. Mathematical work often involves talking and writing about imagined things—such as infinity, zero, infinite lines, or lines that never meet—as well as visualizing shapes, objects, and relationships that may not exist in front of our eyes.

We should not confuse “mathematical” with “formal” or “textbook” definitions. Formal definitions and ways of talking are only one aspect of academic mathematical Discourse practices. Some of the characteristics summarized above may be particular to the end point of producing mathematics, such as making a presentation or publishing a proof, while others are characteristics of the discourse practices involved in the process of producing mathematics.

In general, when describing everyday and academic mathematical Discourse
practices, it is important to avoid construing this as a dichotomous distinction (Moschkovich, 2007c). This distinction is not intended to be a tool to categorize utterances as originating in particular experiences. During mathematical discussions, students use multiple resources from their experiences both in and out of school. It is difficult, if not impossible, to use this distinction to describe the origin of student talk. It is not always possible to tell whether a student's competence in communicating mathematically originated in her everyday experiences or her school experiences. Similarly, we cannot identify whether the meaning for any given utterance originated in everyday or school activity.

The existence of multiple meanings and practices across everyday and math classroom settings has sometimes been described as creating obstacles in classroom mathematical discussions because students are often using colloquial meanings, while teachers (or other students) are using mathematical meanings. However, we should not assume that the everyday meanings and experiences are necessarily obstacles; they also provide resources for communicating mathematically. Everyday Discourse practices should not be seen only as obstacles to participation in academic mathematical Discourse. The origin of some mathematical Discourse practices may be everyday experiences and practices. Some aspects of everyday experiences can provide resources in the mathematics classroom, as we have suggested earlier in the chapter. Everyday experiences with natural phenomena can be resources for communicating mathematically. For example, climbing hills is an experience that can be a resource for describing the steepness of lines (Moschkovich, 1996). Other everyday experiences with natural phenomena also may provide resources for communicating mathematically.

In addition to experiences with natural phenomena, O'Connor (1999) proposes that students' mathematical arguments can be at least partly based on what she calls argument proto-forms:

Experiential precursors (arguments outside of school, the provision of justification to parents and siblings, the struggle to name roles or objects in play) may provide the discourse 'protoforms' that students could potentially build upon in the mathematical domain. (O'Connor, 1999, p. 27)

What about vocabulary? We alluded to vocabulary early on in this discussion. While vocabulary is necessary, it is not sufficient. It must be clear by now that learning to communicate mathematically is not merely or primarily a matter of learning vocabulary. During discussions in mathematics classrooms students are also learning to describe patterns, make generalizations, and use representations to support their claims. The question is not whether students who are English learners should learn vocabulary but how instruction can best support them as they learn both vocabulary and mathematics.

Vocabulary drill and practice are not the most effective instructional practices for learning vocabulary. Instruction should provide opportunities for students to actively use mathematical language to communicate about and negotiate meaning for mathematical situations. Researchers who study vocabulary learning and teaching report that vocabulary acquisition occurs most successfully through instructional contexts that are language rich, actively involve students in using language, require both receptive and expressive understanding, and require students to use words in multiple ways over extended periods of time (Blachowicz & Fisher, 2000; Pressley, 2000). To develop written and oral communication skills students need to participate in negotiating meaning (Savignon, 1991) and in tasks that require output from students (Swain, 2001). Instruction should provide opportunities for students to actively use mathematical language to communicate about and negotiate meaning for mathematical situations. In sum, vocabulary instruction is necessary but not sufficient for supporting mathematical communication. Because mathematical Discourse practices are central to success in mathematics, teachers need to balance vocabulary instruction with modeling of and opportunities for student participation in mathematical Discourse practices.

Conclusion

We have outlined and described some of the important aspects of what mathematics teachers need to know about language and culture. Teachers need to have some knowledge of local communities, take a cultural affirmation approach to differences, and be careful of generalizations and assumptions about cultural or linguistic practices. Teachers also need to be aware of the cultural content of the lessons they teach, consider the cognitive resources provided by both community and discipline practices, and examine how the social organization of the classroom affords or constrains student participation in mathematical activities. Mathematics teachers who work in communities where students are bilingual or learning English also need to understand the nature of bilingualism, be aware of common language practices among bilingual students, and know that all students can participate in mathematical discourse, even as they are learning English.

Even a brief foray into the realm of culture, language, and mathematics teaching and learning illustrates the breadth, depth, and complexity of what teachers need to know to teach mathematics successfully with the range of students in today's classrooms. Few teachers have the opportunity to develop deep understandings of culture and language and each teacher cannot be expected to know everything about each and every cultural and linguistic aspect of their students' lives and experiences. However, teachers can be aware that there are differences and similarities among students, that some of these differences may be relevant for the classroom, and that some differences may be relevant for teaching and learning mathematics. Teachers can also value community knowledge and ways of using language and collaborate with colleagues and people in local communities to learn as much as possible about the students and families they serve. If they do even just one of these, they will be making great strides toward designing mathematics teaching that meets the needs of all their students.
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Notes

1. Of course, many other students—such as African Americans and Appalachians—speak a home dialect that is different from the dialect privileged in the classroom. Associated with a different dialect are differences not only in pronunciation and grammar but also in how language is used in various social settings including school.
2. A language register is a variety of speech associated with a particular setting (e.g., religious setting, courtroom, social get-together, mathematics classroom).
3. In reality, this division may not be quite so neat and tidy.
4. Moschkovich (2007c) uses the phrase “Discourse practices” to emphasize that Discourse is not individual, static, or refers only to language. Instead, she assumes that Discourses are more than language, that meanings are multiple and situated, that Discourses occur in the context of practices, and that practices are tied to communities. Thus, mathematical Discourse practices are connected to multiple communities.
5. The labels used to refer to different mathematical Discourse practices, such as everyday, professional, academic, and school, can be misleading. The terms are complex and contested, and the categories are not mutually exclusive. “Professional mathematical discourse” refers to how mathematicians talk and act. “School mathematical discourse” refers to how students and teachers who are competent in school mathematics talk and act. For a more detailed discussion of multiple mathematical Discourse practices see Moschkovich (2002b, 2007c).

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The Politics of Mathematics Education in the United States
Dominant and Counter Agendas

ERIC GUTSTEIN

At present the United States faces no global rival. America’s grand strategy should aim to preserve and extend this advantageous position as far into the future as possible. Project for a New American Century (2000, p. i)

The above quote succinctly summarizes the goal, if not the reality, of post-World War II (at least) U.S. administrations, as well as that of the financial and corporate elites in the country. However, the context of the quote is about “rebuilding America’s defenses,” and it refers to military rivals. As such, it may have neglected what U.S. capital and government now do consider to be genuine global rivals—but on the economic rather than the military front. These competitors include China, Russia, Brazil, India, Japan, South Korea, and the European Union, and depending on various trade agreements, industries, and other particularities, also include other nations. There is substantial contention between the United States and others for investment possibilities, markets, natural resources, tax breaks, cheap labor sources, and locales with lax environmental regulations. U.S. corporations, like those around the world, consistently vie with others for these opportunities, and economic competition is fierce. Trade skirmishes regularly take place in international arenas like the World Trade Organization. In addition, the United States uses to its advantage both the World Bank and International Monetary Fund, both of which it dominates by having the largest share of votes (by far), as well as a permanent seat on their governing boards (similar to permanent UN Security Council members). In short, global contention is omnipresent (Harvey, 2005).

The perceived threat and onslaught by economic rivals, however, has an
Culturally Responsive Mathematics Education

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