Crossing Borders
Visualizing School Mathematics Outside the Classroom Walls

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Evidence suggests that primary school teachers and their students have difficulty connecting school mathematics with real world, community, professional, and culturally-based ethnomathematical practices (Civil & Bernier, 2006; D'Ambrosio, 2006b; Gutstein, 2007). At the same time, teachers and students are often unable to effectively integrate school mathematics and the mathematics embedded in technology (FitzSimons, 2002; Friedman, 2005; Skovsmose, 2005). For example, both the Numbers and Operations standard and the Algebra Standard of the *Principles and Standards of for School Mathematics* (National Council of Teachers of Mathematics, 2000) suggest that teachers help students consider what numbers mean through the exploration of patterns and relationships. These ideas are often introduced as students grapple with non-decimal number systems, including binary, octal, and hexadecimal systems. Students attempt to add and subtract within these systems, but rarely are they encouraged to consider where and how these systems are embedded in the technology that surrounds us, such as the simple on/off circuitry in electrical power switches to generation of visual images on television and other display screens. Outside of the typical primary school classroom, standard mathematical concepts are differentially applied, using alternative nomenclature and rationale to describe concepts, thereby masking the underlying abundance of mathematical ideas to which they relate in many classroom experiences (Gainsburg, 2006; Gerofsky, 2006; Masingila, 1996; Nicol, 2002; Noss, Hoyles, & Pozzi, 2002; Shockey, 2006).

More prosaically, primary and early secondary teachers recognize how out-of-school experiences integrate with language arts, social studies, and science content (Kennedy, 2006) to help students make connections between classroom curriculum and real world experiences. The classroom vocabulary in these disciplines, particularly for language arts and social studies, is part of the "real world" vocabulary, thereby giving students and teachers the ability to translate school learning beyond the walls of the classroom. However, teachers are less likely to make similar connections between mathematics taught in school (i.e., "school math") and the mathematics that underlies real-life day-to-day experiences (Gerofsky, 2004, 2006; Koirala & Bowman, 2003). More often than not, U. S. teachers neither have the vocabulary nor the breadth and depth of experience to offer their students entry into the community of mathematical thinking outside of the school classroom.

"School math" is generally recognized by both teachers and students as an entity separate from much of the "real world" (Bishop, Clarke, Corrigan, & Gunstone, 2006; Empson, 2002; National Council of Teachers of Mathematics, 2006; National Mathematics Advisory Panel, 2008). In effect, "school math" is its own ethnomathematical community that shares little with the vocabulary and practices utilized in other professional and socially identifiable ethnomathematical communities. U. S. elementary school teachers compared to Chinese counterparts have limited mathematical vocabularies (Ma, 1999) and have difficulty recognizing how school mathematics is a necessary precursor for understanding and participating in the maintenance and development of technological activities in all fields (Nicol, 2002; Skovsmose, 2005). Thus, teachers have a difficult time bringing out-of-classroom mathematics into the classroom, and vice versa, and, as a result, mathematics classrooms have become bounded communities: what is taught and learned in the classroom is tied to out-of-school experiences only in superficial (e.g., games) or overt (e.g., making change) ways. Connections between school and professional experiences are often ignored because the practices of school mathematics are not immediately visible in real-world activities. If connections between "school-mathematics" and "out-of-school mathematics" are weak at best, then students are less likely to recognize that school mathematics can prepare them for opportunities and careers that are less immediately recognized as involving mathematics. Hence, it seems advisable for teachers to initiate and nurture the connections early in children's school years.

Perhaps more an influence, than a connection in the usual fashion, of mathematics education with the world outside the classroom is that it may contribute to or detract from the cultivation and nurturance of democratic citizenship that seeks and supports high quality education for all (Delpit, 2006; Gutstein, 2007; Hannaford, 1998; Stone, 1998; Valero, 2001). Access to equitable mathematics education for all children, especially but not limited to children marginalized by language, poverty, transiency, and/or special needs, demands incorporation of more explicitly inclusive classroom practices that recognize a variety of mathematical visions, vocabularies, and understandings (Barton, Tan, & Rivert, 2008). Such equitable practices ensure that all students are able to recognize and participate in the aforementioned opportunities and career preparations while simultaneously offering them possibilities for intellectual exploration and growth within their own understanding of mathematics and community.

While current mathematics curricula perhaps support "high level thinking," both as an entity unto itself and as preparation for state-sanctioned exams, the explicit mathematics that is needed to create, develop, and support technological growth, change, and innovation is neither recognized, understood, nor supported in most mathematics classrooms. If teachers do not understand the relationship between school mathematics and professional practices that include mathematics and mathematical thinking, then (and unfortunately), their students likely are offered at most opportunities to explore just the edges of ethnomathematical communities of practice across educational and professional contexts.

A recent project (Garii, Burrell, & Tripathi, 2007) asked primary school teachers to articulate the connection between their classroom mathematical practices and students' real world experiences. Specifically, they were asked to link the curriculum they were mandated to teach and their understanding of NCTM standards (National Council of Teachers of Mathematics, 2006) with mathematics practices outside of the classroom.

How do teachers recognize mathematics in the world outside of their classroom? Not surprisingly, teachers had difficulty articulating "real world mathematics" that does not come out of textbooks. Their ideas are based on standard textbook exercises, such as fractional pizzas, proportional (and not necessarily logical) thinking associated with cooking (e.g., 1.75 eggs), and the classification of shapes in the constructed world, such as traffic signs, utility hole covers, and doors and windows. These ideas tend to be both artificial and trivial compared to actual uses of mathematics, such as how engineers determine the number and shape of support beams when designing large buildings (Gainsburg, 2006) or calculating how many widgets can be produced in a minute, given a specific set of restrictions and flexible rules (FitzSimons, 2002).

What are the processes that teachers use to translate the mandated mathematics curriculum to real world mathematical practices? Teachers could not disentangle the mathematics from the reasons for using the mathematics. For example, teachers prioritized student understanding of "charts and graphs" or "percent discount" within a decontextualized framework. Teachers ask students to solve problems based on real-world phenomena (such as ownership of material goods), but do not help students recognize how the associated mathematical representations hold meaning beyond formulaic mathematical presentation. Nor do they consider how these representations may or may not be appropriate for the alleged context being considered. Too often, the process that teachers use to translate school math to real world practices is relegated to finding a single, correct answer to solve a given problem, and sometimes the problems don't matter much to school children. Students, themselves, can certainly play a role in choosing real world experiences to explore, and teachers can become more cognizant of youngsters activities in which mathematics is abundant. Probably mathematics and science concepts that arise in the ethnomathematics of skateboarding (Drexel School of Education, 2008), for example, would likely be of more interest to learners than would be calculating the amount of tax on a restaurant bill, and would engage them in more sophisticated problem solving and higher order thinking, as well. Certainly, target situations for mathematics explorations sometimes raise unexpected issues, that, if handled well, add depth, breadth, and context to students' understanding of how mathematics is utilized in society for decision making and, perhaps, marginalization.

For example, students are often asked to present a graph of the number of pets, books, or cars their families own. While this may appear to be an easy graph to prepare within the classroom, students' responses to the questions of pets, books, and cars may raise questions about income disparities, family expectations, and cultural values that are difficult to map onto a graph. These issues are neither acknowledged nor discussed, although the graphs illustrate inequities and/or differences in the lives of the students.

Together, these inferences suggest that teachers in this study continue to isolate school mathematics from real world mathematical practices: they do not introduce students to the ideas of variability of solutions nor do they help students understand how the parameters may vary and how context may influence the solution processes and interpretation of results. Moreover, these practices are likely to hinder the development, cultivation, and maintenance of good citizenship, democratic ideals and practices, and inclusiveness (Silverman, Fertig, Harding-DeKam, & Thompson, 2007). In effect, mathematics education has a history of being an elitist discipline that has had the effect of advantaging some students while disadvantaging others by the processes and practices of the classroom. That is, many students have encountered school mathematics in formal mathematics lessons, during which limited attention has been paid to developmental, cultural, or social appropriateness (Civil & Bernier, 2006; Gutstein, 2006; Silverman et al., 2007; Valero, 2001, 2008).

Teachers are at the forefront of maintaining or changing societal norms (Bransford, Brown, & Cocking, 2000; Christiansen, 2007). Incorporating ethnomathetical ideas and practices into classroom pedagogies encourages teachers to be aware of the ways in which all peoples – including children and out-of-school formal and informal users of mathematics – integrate their immediate ethnomathematical communities into their understanding of mathematical ideas. Recognition of varieties of community- and professionally-based ethnomathematical vocabularies and practices offers students alternative techniques with which to explore the world around them.

Let us explore the edges between school, technological, and professional uses of mathematics practice and help primary school teachers negotiate that border line so that students can recognize that school mathematics connects with their lives through a complementary relationship between academic mathematics and ethnomathematics (D'Ambrosio, 2006a). Specifically, let this paper open three questions raised by the inclusion of ethnomathematical ideas in the classroom. First, what is the enactment of ethnomathematical practice in the primary or elementary school classroom. Too often, ethnomathematics is narrowly defined as the exploration of historical mathematical ideas and practices (e.g., Mayan math or the mathematics of traditional games). Second, how might the broadening of our understanding of "ethnomathematics" allow students and teachers to explore the abundance and detail of mathematics used naturally in real world practices, both implicitly and explicitly. And third, by widening the definition of "acceptable mathematical practices and experiences in schools" to include ethnomathematical ideas from different cultural, professional, vocational, and avocational communities, how, if, and why does the field of mathematics itself become more accessible and more "real," particularly to aspiring teachers, inservice teachers, and their primary and elementary school students?

References

Barton, A. C., Tan, E., & Rivert, A. (2008). Creating hybrid spaces for engaging school science among urban middle school girls. *American Educational Research Journal*, *45*(1), 68-103.

Bishop, A. J., Clarke, B., Corrigan, D., & Gunstone, D. (2006). Values in mathematics and science education: researchers' and teachers' views on the similarities and differences. *For the Learning of Mathematics, 26*(1), 7-11.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2000). *How People Learn: Brain, Mind, Experience, and School*. Washington D.C. : National Academy Press.

Christiansen, I. M. (2007). Some tensions in mathematics education for democracy. *TMME Monograph 1*, 49-62.

Civil, M., & Bernier, E. (2006). Exploring images of parental participation in mathematics education: challenge and possibilities. *Mathematical Thinking and Learning, 8*(3), 309-330.

D'Ambrosio, U. (2006a). *Ethnomathematics*. Rotterdam: Sense Publishers.

D'Ambrosio, U. (2006b). The program ethnomathematics: a theoretical basis of the dynamics of intra-cultural encounters. *The Journal of Mathematics and Culture, 1*(1), 1-7.

Delpit, L. (2006). Lessons from Teachers. *Journal of Teacher Education, 57*(3), 220-231.

Drexel School of Education. (2008). *The Math Forum Internet Mathematics Library*. Retrieved April 26, 2008, from http://mathforum.org/library/

Empson, S. B. (2002). Is Teaching Mathematics for Understanding Sufficient? *Journal of Curriculum Studies, 34*(5), 589-602.

FitzSimons, G. E. (2002). *What counts as mathematics? Technologies of power in adult and vocational education* (Vol. 28). Boston: Kluwer Academic Publishers.

Friedman, R. (2005, April 26). Mix Math and Medicine and Create Confusion*. The New York Times*, p. D11.

Gainsburg, J. (2006). The mathematical modeling of structural engineers. *Mathematical Thinking and Learning, 8*(1), 3-36.

Garii, B., Burrell, M., & Tripathi, P. (2007). Elementary school teachers discuss mathematics: crossing the border between the classroom and the world. Oswego, NY: State University of New York, Oswego.

Gerofsky, S. (2004). *A Man Left Albuquerque Heading East*. New York: Peter Lang.

Gerofsky, S. (2006). Communication: simulation, reality, and mathematical word problems. *For the Learning of Mathematics*, *26*(2), 30-32.

Gutstein, E. (2006). "The real world as I have seen it": Latino/a parents' voices on teaching mathematics for social justice. *Mathematical Thinking and Learning, 8*(3), 331-358.

Gutstein, E. (2007). Connecting community, critical, and classical knowledge in teaching mathematics for social justice. *TMME Monograph*, *1*, 109-118.

Hannaford, C. (1998). Mathematics Teaching is Democratic Education. *Zentralblatt fur Didaktik der Mathematiks, 98*(6), 181-187.

Kennedy, M. M. (2006). Knowledge and vision in teaching. *Journal of Teacher Education, 57*(3), 205-211.

Koirala, H. P., & Bowman, J. K. (2003). Preparing middle level preservice teachers to integrate mathematics and science: problems and possibilities. *School Science and Mathematics*, *103*(3), 145-154.

Ma, L. (1999). *Knowing and teaching elementary mathematics: teachers' understanding of fundamental mathematics in China and the United States*. Mahwah, N.J.: Lawrence Erlbaum Associates.

Masingila, J. O. (1996). *The mathematics practice of carpet layers: a closer look at problem solving in context.* Paper presented at the Annual Meeting of the American Educational Research Association, New York.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics. (2006). *Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics*. Reston, VA: National Council of Teachers of Mathematics.

National Mathematics Advisory Panel. (2008). *Foundations for Success: The Final Report of the National Mathematics Advisory Panel*. Washington, DC: U.S. Department of Education.

Nicol, C. (2002). Where's the math? Prospective teachers visit the workplace. *Educational Studies in Mathematics, 50*, 289-309.

Noss, R., Hoyles, C., & Pozzi, S. (2002). Abstraction in expertise: a study of nurses' conceptions of concentration. *Journal for Research in Mathematics Education, 33*(3), 204-229.

Shockey, T. (2006). Left-ventricle reduction through an ethnomathematics lens. *For the Learning of Mathematics, 26*(1), 2-6.

Silverman, F. L., Fertig, G. H., Harding-DeKam, J., & Thompson, S. C. (2007). Advancing equity and high quality mathematics education with actions drawn from ethnomathematics. *TODOS: Mathematics for All, 3*(2), 1-2.

Skovsmose, O. (2005). Foregrounds and politics of learning obstacles. *For the Learning of Mathematics, 25*(1), 4-10.

Stone, C. (1998). Leveling the playing field: an urban school system examines equity in access to mathematics curriculum. *The Urban Review, 30*(4), 295-307.

Valero, P. (2001). Social Justice and Mathematics Education: Gender, Class, Ethnicity, and the Policy of Schooling. *ZDM, 33*(6), 187-191.

Valero, P. (2008). *In between reality and utopia: a socio-political research agenda for mathematics education in situations of conflict and poverty* Paper presented at the Fifth International Mathematics Education and Science Conference, Lisboa.