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In opposition to neoliberal forces that are furthering homogenization of mathematics education worldwide as part of globalization, we argue for the necessity of maintaining diversity in all its human forms, including in mathematics and mathematics education. Central to this position is respect is the conception of mathematics and mathematics education as human activities, inextricably embedded in forms of life.

Keywords: Diversity, cultural responsiveness, ethnomathematics.

INTRODUCTION: GEOPOLITICAL BACKGROUND

Among the most salient aspects of education in the United States and many other parts of the world are: privatization and corporatization of public education, with associated profiteering by IT and publishing corporations; homogenization that ignores all forms of diversity; as well as excessive and irrational use of high-stakes standardized tests (Apple, 2000; Picciano & Spring, 2013; Spring, 2008).

Aspects that bear particularly on mathematics education include:

- homogenization of the mathematics curriculum, reinforced by international testing
- pervasive rhetoric about the necessity of high levels of formal mathematics education, typically phrased as essential for economic competitiveness in the global marketplace
- unwarranted weight afforded to performance on tests of mathematics as a gatekeeper to educational and economic opportunities
- continuing perception of mathematics as acultural, and academic mathematics as a purely European achievement

In this paper, we present a counterposition.

MATHEMATICS AND MATHEMATICS EDUCATION AS HUMAN ACTIVITIES

We take it as axiomatic that mathematics itself, and mathematics education, are human activities, embedded in historical, cultural, social, and political contexts. Accordingly, we argue for mathematics education that valorizes diversity in all its forms, stemming from diversity in forms of life, that we term "culturally responsive mathematics education" (CRME). In opposition to the corporate goal of (mathematics) education as a means to increase human capital, we would redirect it towards increasing human capability, which Sen (1997, p. 35) defined as "the ability of human beings to lead lives they have reason to value and to enhance the substantive choices they have". In short, we argue for humanization of mathematics education.

Mathematics as cultural construction

> [...] mathematics must be understood as a human activity, a social phenomenon, part of human culture, historically evolved, and intelligible only in a social context (Hersh, 1997, p. xi).

Particularly since the 1980s, the position expressed by Hersh has been articulated among teachers, scholars, and researchers who critique the sociopolitical systems of mathematics education. Central to the concerns we raise in this paper is the Ethnomathematics movement, essentially launched when Ubiratan D'Ambrosio gave a plenary talk at the International Congress on Mathematical Education in Adelaide in 1984 on "Socio-Cultural Bases for Mathematical Education", and the conference included an extra day

on the theme "Mathematics Education and Society". Shortly afterwards, in another key work, Bishop (1988) framed mathematics education as enculturation and identified counting, measuring, locating, playing, designing, and explaining as mathematical activities found in essentially all cultures.

One definition is that:

> Ethnomathematics is the mathematics practiced by cultural groups, such as urban and rural communities, groups of workers, professional classes, children in a given age group, indigenous societies and so many other groups that are identified by the objectives and traditions common to these groups (D'Ambrosio, 2006, p. 1).

Thus, although much of the work in Ethnomathematics analyses mathematical aspects of practices in non-industrial societies, it also applies to cultural groups in the industrialized world. For example, carpenters in many cultures operate very efficiently, when measuring or designing, with decimal fractions or binary fractions such as ¾ and $^{5}/_{16}$ – they never need to calculate something like $^{3}/_{7} + {}^{4}/_{11}$. From this perspective, it must be considered a major weakness in mathematics education as typically practiced in many parts of the world that there is a lack of connection between what happens in schools and the lived cultural and sociopolitical experience of students, their families, and their communities, and, for most people, their future lives.

Emphatically, the statement just made in no way negates society's need for a cadre of people with mathematical expertise to provide the benefits that come from technological advances (and indeed to advance mathematics as a discipline that continues to evolve (Hersh, 2006)). What seems absurd to us is pervasive rhetoric (in which many in our own field join) about the need for *all* students to learn substantial amounts of technical mathematics, ignoring the most obvious fact about any society, namely that it relies on people filling a diversity of roles. Thus, instead of a soundbite such as "algebra for all", we would suggest a less catchy, but more real, slogan like "a great deal of algebra for a few, a lot of algebra for a larger number, and the opportunity to learn useful algebra for everyone" together with the understanding that lack of performance in formal algebra should not be a barrier to lives and careers for which it is not necessary. We also suggest that the opportunities for Internet-based learning, including courses delivered by top mathematicians, are ideally suited for the nurturing of the next generation of mathematically gifted students, who are typically self-motivated.

While the study of mathematical practices among cultural groups may be defined as the essence of Ethnomathematics, from its inception another focus has been the construction of a counter-narrative to the Eurocentric – indeed, arguably, racist (Raju, 2007) – account of the history of the development of academic mathematics, as addressed in the collection of key papers edited by Powell and Frankenstein (1997). Historians have documented the contributions of many cultures, including Indian, Chinese, and Arab, to the development of academic mathematics in Europe (Joseph, 1992; Raju, 2007). In other parts of the world, very sophisticated and elaborate systems of mathematics, astronomy, navigation, engineering, and science, were developed across millennia. D'Ambrosio (1985) pointed out that colonialism grew in a symbiotic relationship with modern science, in particular mathematics and technology, and Bishop (1990) characterized mathematics as a tool of imperialism. Mathematics was, and remains, a powerful way to convey the supposed intellectual superiority of Europeans and cultural groups deriving from them. Accordingly, the rewriting of history of mathematics is essential, not just as a matter of truth and justice, but also because the continuing belief in the intellectual inferiority of non-White people as doers of mathematics, deeply and unconsciously rooted among the colonizers and internalized by the colonized, is an obstacle to the construction of the identity of a non-White person as a doer of mathematics, for example an African or Asian immigrant in a European school.

Humanizing mathematics education

Mathematics education, like mathematics, is a human activity – indeed, even more so, given the centrality of interpersonal relationships in learning/teaching. An adequate analysis of the relationship between mathematics-as-discipline and mathematics-as-school-subject is beyond the scope of this paper; we simply state our convictions that mathematics education is not reducible to the immaculate transmission of a structured body of knowledge from experts to learners, and that mathematicians may be necessary, but are certainly not sufficient, when it comes to framing mathematics education.

Paulo Freire's observation that "education is politics" (Freire & Macedo, 1987, p. 47) applies specifically to mathematics education in many ways, with far-reaching consequences. A very important case is the extent to which so many aspects of modern life are governed by mathematical models that are often invisible to, and almost always beyond the control of, most people – what Skovsmose (2005, p. 86) termed "mathematics in action". We have argued elsewhere (Greer & Mukhopadhyay, 2012) that mathematics education predominantly fails to prepare students to become citizens with a critical disposition to understand, and agency to disrupt, misapplied mathematical models, for example in relation to economics. We would argue that this failure in mathematics education serves to protect political systems from critique. By contrast, Gutstein (2012), operating in the spirit of Freire, has shown how mathematics can become a weapon in the struggle for social justice by teaching students how it can be a tool for analyzing and then acting upon, issues of importance in their sociopolitical reality (reading and writing the world, in Freirean terms).

To raise another political theme in relation to mathematics education, there is pervasive rhetoric across the world to the effect that advanced levels of mathematics (and science) education are essential for all students for a given country's economic survival in a globally competitive world. Indeed, within the United States of America, this rhetoric is increasingly couched in terms of threats to national security. Contrast this nationalistic stance with D'Ambrosio's (2010) passionate plea that mathematicians and mathematics educators should collectively be seeking solutions to the crises facing humanity.

CULTURALLY RESPONSIVE MATHEMATICS EDUCATION

In the previous section, we argued for a conceptualization of mathematics as culturally constructed and for humanizing mathematics education, including recognition of its political roles. In this section, we consider, as an important aspect of humanization, making mathematics education culturally responsive. This theme plays out, with variations, all over the world, of which we mention just a few.

As movements of populations increase, for many reasons, children find themselves in complex intercultural life situations. By way of example, Ali (2012) presents a detailed account of a young Pakistani immigrant in Barcelona constructing her mathematical identity and planning her career in a multicultural city, in the context of several languages (Punjabi, Urdu, Catalan, Spanish, English) and having experienced greatly contrasting styles of mathematical instruction in Pakistan and Saudi Arabia before coming to a school in Barcelona in Grade 10.

As a more general example, with the ending of colonialism in its original form in many countries, liberated peoples face the issue of reconciling their cultural identity with the need to be economically competitive. Arguably the clearest example is South Africa (Graven, 2014; Vithal, Adler, & Keitel, 2005). In many other parts of the world, such as South America, Australia, and New Zealand, campaigns for the rights of Indigenous peoples include work on both mathematics education and on Ethnomathematics (Ferreira, 2015), not without many conflicts and dilemmas (Greer, 2013). A very striking manifestation of tension was manifest in a report (Atweh & Clarkson, 2001, pp. 86–87) of interchanges at a conference at which Clements (1995, p. 3) stated that "Over the past 20 years I have often had cause to reflect that it is Western educators who were responsible not only for getting their own mathematics teacher education equation wrong, but also for passing on their errors to education systems around the world". Yet, at the same conference, the president of the African Mathematical Union (Kuku, 1995, p. 407) "warned against the overemphasis on culturally oriented curriculum for developing countries that act against their ability to progress and compete in an increasingly globalized world" (Atweh & Clarkson, 2001, p. 87).

In India, activist academics have been striving to create curriculum and textbooks for elementary mathematics that "address diverse children's knowledge through a (re)humanizing pedagogy of empathy, despite the constraints of a large bureaucratic and increasingly neo-liberal state system" (Rampal, 2015). In the same context, Subramanian raises ethical issues involved in designing and developing a uniform curriculum for an educational system of such a size and with such diversity of languages and cultures.

In the United States of America, since the passing of the legislation "No Child Left Behind" in 2001, intensive use of standardized tests, combined with disaggregation of test scores by ethnicity, has led to

considerable attention being focused on attempts to reduce the differences in test scores among ethnic groups, in particular to raise the test scores of Black, Latino/a, and Native American students. (The usual terminology for such efforts is "closing the achievement gaps" which is problematic for a number of reasons, including connotations of deficit models, the positioning of white students' achievements as the norm, and concerns about the nature of the tests that yield the scores.)

Attention to these aspects has been concentrated by rapid demographic changes – at the time of writing, the US Department of Educational Statistics has just projected that in the coming school year, the proportion of school students that are White (by the classification structure used) will be less than 50%. The teaching population, on the other hand, remains predominantly White, being 83% in 2007.

Against this background, the concept of culturally responsive teaching has made considerable progress within the United States in the last twenty years (Gay, 2010; Ladson-Billings, 1995; Villegas & Lucas, 2002). Contributing to its emergence, movements within critical education that have been foundational include Multicultural Education and Critical Race Theory. The term "Culturally Responsive Mathematics Education" (CRME) originated in a 2004 conference in Washington which we helped to organize, leading eventually to an edited volume (Greer, Mukhopadhyay, Powell, & Nelson-Barber, 2009).

Given that central to all education is the relationship between the student and the teacher, then the cultural and mathematical identities of both students and teachers are of paramount importance, as is the degree to which they do or do not align, particularly in terms of culture, ethnicity, and class. In the context of the United States of America, Gay (2009, p. 189) posed many key questions: "How can middle-class monolingual European-American math[ematics] teachers work better with students who are predominantly of color, attend schools in poor urban communities, and are often multilingual?". Similar questions apply in all educational settings in which there are class, ethnic, and cultural differences between students and their teachers. Gay (2009, p. 194) also stressed that teachers-in-training should examine questions such as "What is it about the way math has been socially constructed that is exclusive, rather than inclusive to culturally, racially, ethnically, and socially diverse students?". She also pointed to the fact that:

> [many students] find it difficult to see the relevance of many math concepts, principles, and operations to real life, when they are perpetually presented as decontextualized formulas and abstractions. Teachers need to be taught how to humanize mathematics, and to place these reconstructions into the lived realities of different racial, cultural, social, and ethnic groups. (p. 195, emphasis added)

There is a conception that an educational system full of human beings, with all the complexity that implies, can be treated as a black-box model controlled by crude external levers of standardized testing designed to expose schools to market forces that will automatically improve education. This conception has its epicentre in the United States of America, but the seismic effects are widespread. Quite apart from the absurdity of such a position, and the lack of any evidence that it is viable, in the context of the current paper, we point out that standardized, mass-administered tests by their nature cannot take account of the diversity of students' lives (Miller-Jones & Greer, 2009).

CONCLUDING THOUGHTS: HONORING DIVERSITY IN MATHEMATICS EDUCATION

We argue for mutual respect for the Other, through:

> [...] celebration of diversity in all its human forms, specifically in relation to mathematics and mathematics education: culture, ethnicity, gender, forms of life, worldviews, cognition, language, value systems, perceptions of what mathematics education is for (Greer, Mukhopadhyay, & Roth, 2012, p. 1).

One way to frame the argument that we are seeking to advance in this paper is to consider interactions between three families of mathematical activities, namely mathematics-as-discipline (MD), mathematics-as-school-subject (MS), and mathematics-within-culture (MC). The simplistic notion held by some mathematicians that the role of MS is simply to pass on the rudimentary contents of MD to another generation, primarily as groundwork for the reproduction of their own species, needs to be confronted because

it exerts unwarranted influence on mathematics education, in our view. Rather, we believe that MC should play a central role in constructing mathematical schooling, a position aligned with the concept of "funds of knowledge" that is based on a simple premise, that "people are competent, they have knowledge, and their life experiences have given them this knowledge" (Gonzalez, Moll, & Amanti, 2005, pp. ix-x).

As argued in this paper, a clear implication of this viewpoint is that diversity in all its forms, of which diversity of forms of life may be considered the bedrock, must be fundamental to mathematical schooling. Skovsmose (2012) draws attention to the variety of sites for learning mathematics, the variety of forms of mathematics in action, and the variety of educational possibilities. With reference to the first, he points out how research discourse in our field is dominated by an unexamined stereotype of "the prototype mathematics classroom" that ignores the reality of many classrooms around the world. The second type of variety that he mentions is an effective response to the question "But isn't mathematics the same everywhere?" which is not tenable if the boundary of mathematics is drawn to include its applications (and, as Raju (2007) has pointed out is negated by the predominant reliance of Western mathematics on two-valued logic, a cultural choice). And the third is central to the argument in this paper.

While we have not enough space within this paper to address linguistic diversity, it is of the greatest importance, not simply in its own right in a world increasingly under the sway of English, but also in relation to issues in multilingual classrooms and the importance of language in framing and communicating thinking, including in mathematics.

Epistemological pluralism is another central issue, even from the perspective of mathematics-as-discipline. Pinxten, van Dooren, and Harvey (1997, pp. 174–5), citing the fundamental different epistemology of the Navajo, in particular in relation to space, point out that diversity is essential in order for evolutionary selective processes to operate in the further development of MD. They comment that "Through a systematic superimposition of the world view and thought system of the West on traditional non-Western systems of thought and action all over the world, a tremendous uniformization is taking hold... The risks we take on a worldwide scale, and the impoverishment we witness is – evolutionarily speaking – quite frightening" (p. 174).

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