GUEST EDITORIAL

Increasing access: the application of multicultural education to STEM

> Today, I want to argue, the most urgent social issue affecting poor people and people of color is economic access. In today's world, economic access and full citizenship depend crucially on math and science literacy. I believe that the absence of math literacy in urban and rural communities throughout this country is an issue as urgent as the lack of registered Black voters in Mississippi was in 1961. (Moses and Cobb, 2002, p. 5)

Robert Moses, Civil Rights activist and founder of the Algebra Project, articulates the necessity of Science, Technology, Engineering and Mathematics (STEM) literacy for underserved communities in the USA. Many scholars argue that education equity and equality is the civil rights issue of this generation. STEM education is currently popular and an influential trend in education, but historically, high quality STEM education has been reserved for the privileged – those identified as gifted or wealthy. Plato explained in Laws, that:

> There still remain three studies suitable for freemen. Arithmetic is one of them; the measurement of length, surface, and depth is the second; and the third has to do with the revolutions of the stars in relation to one another. *Not every one* has need to toil through all these things in a strictly scientific manner, but *only a few* […] yet to enter into these matters minutely is neither easy, *nor at all possible for every one* [author's emphasis]. (Plato, *Laws* Book VII)

Moses explains that algebra served as a gatekeeper to higher mathematics courses. Similarly, Aikenhead (1996, p. 13) explains:

> […] school science (most often physics) can be used to screen out students belonging to marginalized social groups, thereby, providing high status and social power to the more privileged students who make it through the science "pipeline" and enter science-related professions.

Ironically, globalization and economic competition between countries have increased nations' interest in preparing citizens in STEM areas, even citizens in the marginalized communities. The discourse has changed; what was reserved for the elite is now necessary for the masses.

STEM education plays a significant role in creating STEM-literate populace. STEM literacy has tangible consequences for economic mobility. According the US Bureau of Labor Statistics, STEM jobs are expected to grow at a rate of 13 per cent between 2012-2022, higher than the 11 per cent rate of other fields (Vilorio, 2014). During the US recession of 2007-2010, STEM careers were seemingly insulated – when unemployment rose to 10 per cent for other occupations in 2010, STEM fields peaked at 5.5 per cent in 2009 (US Congress Joint Economic Committee, 2012). Beyond jobs and job security, wages are higher in STEM fields. The median income for a STEM occupation was 76,000 in 2013, double the median income of 35,080 for all other occupations in 2013

Journal for Multicultural Education
Vol. 10 No. 3, 2016
pp. 250-256

2053-535X
DOI 10.1108/JME-06-2016-0035

(Vilorio, 2014). Increasing the number of underrepresented populations in STEM careers has the potential to have significant financial implications for those communities.

While STEM knowledge is essential for economic access, Dr Mae Jemison, physician, astronaut and principal of 100 Year Starship, illustrates that it is also critical to have a variety of perspectives involved in the various STEM enterprises. In jest, she gives an example of cancer treatments prevalent when she was in medical school. She explained that the primary treatment for breast cancer was a mastectomy (or removal of the breast). However, during conversations of testicular cancer, there was no suggestion of removal of the testicles. She alluded to the fact that most doctors were men, but as more women became oncologists, the perceptions about the best treatment expanded with mastectomy being a last resort not the first choice. Having more women at the table changed the discussion about how to treat breast cancer.

While the discourse on who STEM is for has changed, the methods of teaching STEM content has not shifted as quickly as the conversation. Multicultural education is a field designed to minimize boundaries that plague marginalized students' access to various types of curricula. James Banks defines multicultural education as a "complex and multidimensional concept" that includes:

- "content integration;
- knowledge construction process;
- prejudice reduction;
- equity pedagogy; and
- empowering school culture and social structure" (Banks, 1993, p. 25).

There are different types of multicultural education, and they have different objectives. Liberal multiculturalism focuses on "getting along better" (May and Sleeter, 2010, p. 4), while critical multiculturalism "gives priority to structural analysis of unequal power relationships, analyzing the role of institutionalized inequalities" (May and Sleeter, 2010, p. 10). The critical perspective aims not only to increase curricular accessibility, but also to teach how various disciplines can be useful in leveraging action for social change.

For years, educators assumed STEM subjects were culture-neutral and multicultural education applied to language arts and social studies but fell beyond the realm of STEM. The first job of multicultural education scholars was to dispel the myths that STEM curricula was culturally-neutral or value-free. Table I shows some of their arguments of how culture is deeply embedded in STEM content areas.

Understanding that STEM content areas are indubitably influenced by culture, it is essential for those who want to increase access to STEM to understand how dissonance between school culture and discipline culture may impact underrepresented groups' engagement with STEM content. In this introduction to the special issue, I will briefly review some ideas on the convergence of STEM and multicultural education while reiterating multicultural approaches to STEM as a tool for increasing access for marginalized communities.

Multicultural content integration in STEM

One of the primary features of multicultural education is the integration of multicultural content. Psychologist Na'im Akbar speaks of the importance of education transmitting a legacy of competence. Students need to see representation of their ancestors'

STEM discipline	Arguments against cultural neutrality
Science	"Too few acknowledge that science and technology (like music, literature, and politics) are human endeavors that influence, and are influenced by, the socio-cultural context in which they are located. . . . the questions we ask, the kinds of problems we perceive and try to solve and so on–depends on who we are and where we are" (Hodson, 1999, p. 785)
Technology	"If computational ideas are shaped by their creators' values, appreciations, ideologies, beliefs or aesthetics, they may vary between cultures. Technological systems are socially produced, and social production is culturally informed. ICT is not a value per se, but only becomes a value when it responds to the needs of a particular group". (Tedre *et al.*, 2006, p. 126)
Engineering	"Engineering education is a culture in which this propensity to separate the technical and the social – the humans and the non-humans – is deeply ingrained. How interwoven people are with any particular engineered product, structure or system, or how completely one will find humans and technologies entangled at every project stage – from initial conception to iterative refinement, dissemination, intended and unintended use". (Adams *et al.* 2011, p. 59)
Mathematics	"Traditionally in mathematics classrooms, the relevance of culture has been strangely absent from content and instruction. The result is that many students and teachers unquestionably believe that no connection exists between mathematics and culture . . . they believe that mathematics is a cultural, a discipline without cultural significance. Mathematics is a compilation of progressive discoveries and inventions from cultures around the world during the course of history". (d'Ambrosio 2001, pp. 309-310)

Table I.
Rebuttals to cultural neutrality arguments in STEM disciplines

contributions to the world and the content. This can be partially achieved with the infusion of multicultural content in the curricula. In mathematics, ethnomathematician d'Ambrosio (2001, p. 310) explains, "Children are seldom taught that several ancient Greek mathematicians, for instance Pythagoras and Thales [. . .] traveled and studied in such places as India and northern Africa". Similarly, ethnocomputing scholars argue that the foundations of computing have existed for millennia and attest "Even the word 'algorithm' was derived from the name of the noted Persian mathematician Mohammed ibn-Musa al-Khwarizmi" (Tedre *et al.*, 2006, p. 127). In science, Hodson (1999, p. 784) explains that one myth science is plagued by is the idea that science is a "Western, post-Renaissance practice". STEM curricula are often presented in diverse contexts with narrow euro-centric conceptions of what constitutes legitimate STEM knowledge. While euro-centric presentations are normalized, Ukpokodu (2011, p. 51) warns that superficial integration of content "that trivializes and stereotypes urban students' (marginalized students') lives and their communities" can be counterproductive to the cause of multicultural education.

Multicultural knowledge construction processes in STEM

Banks (1993) outlines five types of knowledge that teachers should be aware of when teaching: personal/cultural knowledge of their students, popular knowledge, mainstream academic knowledge, transformative knowledge and school knowledge. Knowing there are multiple types of knowledge, educators should not dismiss the knowledge that children bring with them to the classroom, but instead should capitalize upon it. Moll *et al.* (1992) recommend teachers to draw upon funds of knowledge and use household cognitive resources for classroom instruction. Other multicultural education scholars advocate launching instructions with what students already know. In math, that can be beginning with cultural or practical approaches to mathematics (i.e. using sports statistics) and then proceeding to textbook or "scholarly" mathematics (Nasir *et al.*, 2008). When a teacher begins with the student's knowledge, the student experiences success immediately and the value of their personal, cultural or popular knowledge is recognized.

In addition to beginning with what students know, scaffolding is important for knowledge construction in diverse classrooms. In computer science instruction, scholars advise a three-stage process "'use-modify-create' progression to help the learner go from user to modifier to creator of computational artifacts" (Grover and Pea, 2013, p. 40). To increase computational thinking, summarized as, "solving problems, designing systems, and understanding human behavior by drawing on concepts fundamental to computer science" (Wing, 2006, p. 33), educators should consider:

> Curricular activities such as game design and robotics […]. as a means for iterative exploration of CT [computational thinking] […] Visual and tangible programming experiences are often followed by exposure to high-level programming languages such as Python, Java, and Scheme (Grover and Pea, 2013, pp. 40-41).

Comparably, in engineering education, scholars propose that early engineering or developmental engineering should focus capitalizing on:

> […] naturally occurring curiosity […] should be designed to encourage exploration, inquiry, and design […] [and view] Teachers, as crucial partners actively involved in the scaffolding of children's learning (Adams *et al.* 2011, p. 100).

Knowledge construction processes are critical to the success of STEM education endeavors.

Equity pedagogy in STEM

Banks defines equity pedagogy as pedagogical practices that facilitate learning in diverse groups of students. Equity pedagogy would appeal to different learning styles and multiple intelligences as well as incorporate cooperative learning opportunities. Culturally relevant pedagogy is one equitable pedagogical strategy that requires students to experience success, maintain cultural competence and develop critical consciousness (Ladson-Billings, 1995). Critical consciousness is indispensable in the discussion on why multicultural education is so important, especially within the STEM fields. Each STEM field focuses on a type of problem solving, but only individuals literate in that domain determine the priorities of problems to be solved. Access in STEM education is not solely about economic empowerment, but the opportunity to change society. Hodson (1999, p. 787), for example says within the science classroom:

> By grounding the curriculum content in socially and personally relevant contexts – for example, Food and Agriculture; Energy Resources; Land, Water, and Mineral Resources – an issue-based approach can provide the motivation that is absent from current abstract, decontextualized approaches and can form a base for students to construct understanding that is personally relevant, meaningful and important.

Eric Gutstein, noted social justice mathematician, suggests the goal of critical mathematics education is to allow students to "read and write the world with mathematics" in a Freiren sense of conscientization. He explains that students:

> […] should learn rich mathematics so that they can have opportunities to study, pursue meaningful lives, and support their families and communities, but even more, to use mathematics to fight injustice and improve society (Gutstein, 2010, p. 130).

In texts such as Rethinking Mathematics, edited by Gutstein and Peterson, mathematics lessons incorporating issues of justice are presented including topics from number sense to geometry and beyond.

Multicultural education and STEM

The literature on multicultural education and STEM education gives concrete ways to make STEM content more accessible; yet other barriers to successful STEM education exist. When examining teacher attitudes, Yasar and colleagues found that while teachers thought it was important to teach design, engineering and technology (DET), they were not confident in their ability to do so. Moreover, they found "it appears that teachers do think that most people have stereotypical perceptions of the lack of ability of female and minority students to do well engineering", which could be argued to be a projection of their own beliefs (Yasar *et al.*, 2006, p. 212). STEM identity formation is also a barrier to persistence, as students from underrepresented groups often do not feel STEM is "for them" or worse, they experience ostracism first-hand from members of that disciplinary community. While it is not an easy feat to overcome, the eradication of underrepresentation in STEM is one worthy of pursuit. At the core, science, technology, engineering and mathematics are disciplines rooted in a common goal – problem solving.

The contributors to this special issue examine barriers and offer solutions to increase the access to STEM content for diverse learners. As Robert Moses stated, the work included here seeks to assist those trying to increase access for marginalized students to STEM content. In doing so, we hope to decrease prejudice and facilitate economic mobility by making STEM careers within the reach of those in the marginalized sector. Furthermore, we understand access to have significant ramifications beyond individual economic mobility. As Hodson (1993, p. 706) explained:

> The direction of technological change is *not* inevitable and irresistible. We *can* control technology and its environmental and societal impact […] and redirect technology in such a way that […] issues of freedom, equality, and justice are kept in the forefront of discussion during the establishment of policy. We can reorient our science and technology away from reckless pursuit of economic growth toward more humanitarian ends – the alleviation of human misery (poverty, hunger, poor health, political oppression, etc.) – and toward the solving of current environmental problems.

In doing so, we must increase access of those in the margins to have voice within STEM. This is the task of multicultural STEM education.

This issue is divided into three sections. The first section makes the case for considering culture within STEM classrooms. The first two articles examine strategies for knowledge construction in the STEM classroom; Collier, Burston and Rhodes illuminate the applicability of second-language acquisition strategies for teaching science content while Hinnant-Crawford, Faison and Chang look at the importance of co-regulation in the math classroom. Waller and Flood look at the utility of math content bridging cultural barriers; arguing some mathematic principles are universal but not cultural.

The second section is intimately related to the first, not examining culture in the classroom, but asking how we should prepare teachers to be multiculturally competent STEM educators. The articles in this section give special attention to content and pedagogy. Emdin, Adjapong and Levy elevate Reality Pedagogy and show its power when used in conjunction with Hip-Hop Spoken Word Therapy in science classrooms. Yoon, Kim and Martin present a model for creating opportunities for pre-service teachers to develop multicultural science lessons for students who vary in English proficiency. Greene-Clemmons's research shows that despite age differences, most pre-service teachers, in a preparation program geared toward preparing culturally responsive teachers, develop favorable attitudes toward technology integration in the classroom.

In a conscious attempt to not privilege STEM influences that occur within schools, the penultimate section examines the contributions to STEM education that occur outside the traditional classroom, examining ideas within homes and community spaces. The scholarship of Hernandez, Rana, Alemdar, Rao and Usselman dispel myths that Latino parents do not value STEM education and are uninterested in their children pursuing post-secondary STEM education. Williams, Burt and Hilton examine role strain in relation to math achievement and argue that for scholars and educators to really impact outcomes, a more nuanced understanding of factors contributing to achievement is essential. Wright, Counsell, Goings and Freeman illuminate strengths in out-of-school time and community resources. Flowers and Banda explore the sources of self-efficacy in development of STEM identity.

Finally, co-editor Pogue concludes this special issue by acknowledging immediate needs in multicultural STEM scholarship, calling scholars to continue to explore non-Western traditions in STEM, and educators to adopt STEM-C strategies as a part of their practice. It is our sincere desire that the scholarship within serves as a catalyst to increase STEM access for traditionally marginalized students.

Brandi Nicole Hinnant-Crawford
Department of Human Services, Western Carolina University, Cullowhee, North Carolina, USA

References

Adams, R., Evangelou, D., English, L., Figueiredo, A.D., Mousoulides, N., Pawley, A.L., Schiefellite, C., Stevens, R., Svinicki, M., Trenor, J.M. and Wilson, D.M. (2011), "Multiple perspectives on engaging future engineers", *Journal of Engineering Education*, Vol. 100 No. 1, pp. 48-88.

Aikenhead, G. (1996), "Science education: border crossing into the subculture of science", *Studies in Science Education*, Vol. 27 No. 1, pp. 1-52.

Banks, J.A. (1993), "Multicultural education: historical development, dimensions, and practice", *Review of Research in Education*, Vol. 19, pp. 3-49.

d'Ambrosio, U. (2001), "What is ethnomathematics, and how can it help children in schools?", *Teaching Children Mathematics*, Vol. 7 No. 6, p. 308.

Grover, S. and Pea, R. (2013), "Computational thinking in K-12 a review of the state of the field", *Educational Researcher*, Vol. 42 No. 1, pp. 38-43.

Gutstein, E. (2010), "Critical multicultural approaches to mathematics education in urban, K-12 classrooms", *Critical Multiculturalism: Theory and Praxis*, p. 127.

Hodson, D. (1993), "In search of a rationale for multicultural science education", *Science Education*, Vol. 77 No. 6, pp. 685-711.

Hodson, D. (1999), "Going beyond cultural pluralism: science education for sociopolitical action", *Science Education*, Vol. 83 No. 6, pp. 775-796.

Ladson-Billings, G. (1995), "But that's just good teaching! The case for culturally relevant pedagogy", *Theory into Practice*, Vol. 34 No. 3, pp. 159-165.

May, S. and Sleeter, C.E. (Eds). (2010), *Critical Multiculturalism: Theory and Praxis*, Routledge, Abingdon.

Moll, L.C., Amanti, C., Neff, D. and Gonzalez, N. (1992), "Funds of knowledge for teaching: using a qualitative approach to connect homes and classrooms", *Theory into Practice*, Vol. 31 No. 2, pp. 132-141.

Moses, R. and Cobb, C.E. (2002), *Radical Equations: Civil Rights from Mississippi to the Algebra Project*, Beacon Press, Boston, MA.

Nasir, N.I.S., Hand, V. and Taylor, E.V. (2008), "Culture and mathematics in school: boundaries between cultural and domain knowledge in the mathematics classroom and beyond", *Review of Research in Education*, Vol. 32, pp. 187-240.

Tedre, M., Sutinen, E., Kähkönen, E. and Kommers, P. (2006), "Ethnocomputing: ICT in cultural and social context", *Communications of the ACM*, Vol. 49 No. 1, pp. 126-130.

Ukpokodu, O.N. (2011), "How do i teach mathematics in a culturally responsive way? Identifying empowering teaching practices", *Multicultural Education*, Vol. 19 No. 3, pp. 47-56.

US Congress Joint Economic Committee (2012), *STEM Education: Preparing for the Jobs of the Future*, Washington, DC.

Vilorio, D. (2014), "STEM 101: intro to tomorrow's jobs", *Occupational Outlook Quarterly*, Vol. 58 No. 1, pp. 2-12.

Wing, J.M. (2006), "Computational thinking", *Communications of the ACM*, Vol. 49 No. 3, pp. 33-35.

Yaşar, Ş., Baker, D., Robinson-Kurpius, S., Krause, S. and Roberts, C. (2006), "Development of a survey to assess K-12 teachers' perceptions of engineers and familiarity with teaching design, engineering, and technology", *Journal of Engineering Education*, Vol. 95 No. 3, pp. 205-216.

Further reading

Baillie, C., Ko, E., Newstetter, W. and Radcliffe, D.F. (2011), "Advancing diverse and inclusive engineering education practices through interdisciplinary research and scholarship", *Journal of Engineering Education*, Vol. 100 No. 1, pp. 6-13.

Diaz, N.V. and Cox, M.F. (2012), "An overview of the literature: research in P-12 engineering education", *Advances in Engineering Education*, Vol. 3 No. 2, pp. 1-37.

CSTA (2010), "Running on empty: the failure to teach K-12 computer science in the digital age", available at: http://csta.acm.org/Runninonempty/