Culturally Responsive STEM Education

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Amy Wilson-Lopez, Utah State University

Culturally Relevant Education

Recently, Aronson and Laughter (2016) conducted a synthesis of culturally relevant education in mathematics, science, social studies, language arts, and English as a Second Language. They used the term **culturally relevant education** to encompass other terms that describe social justice-oriented pedagogies, the most popular of which are *culturally responsive teaching* (Gay, 1975, 2013) and *culturally relevant pedagogy* (Ladson-Billings, 1995, 2014).

In summarizing and synthesizing this body of work, Aronson and Laughter stated that culturally relevant educators:

- use constructivist methods to develop bridges connecting students' cultural references with *academic skills and concepts.*
- engage students in *critical reflection* about their own lives and societies.
- facilitate students' *cultural competence*, which refers to "helping students to recognize and honor their own cultural beliefs and practices while acquiring access to the wider culture" and to STEM cultures (Ladson-Billings, 2006, p. 36).
- unmask and unmake oppressive systems through the *critique of discourses of power.*

Culturally sustaining pedagogy (Paris, 2012) shares commonalities with culturally responsive or relevant education with three differences (Paris & Alim, 2014):

- It foregrounds students' cultural practices, and it seeks the maintenance of these cultural practices as a primary goal, rather than using them solely as bridges to academic practices or hybrid practices.
- It seeks to "honor, explore and extend" heritage practices and evolving contemporary practices (e.g., Hip Hop), rather than focusing exclusively on heritage practices (Paris & Alim, 2014, p. 87).
- It encourages students to reflectively critique both dominant and non-dominant cultural practices (e.g., those related to homophobia, racism, xenophobia, and misogyny), rather than focusing exclusively on the critique of dominant cultural practices.

In all cases, culturally responsive/relevant/sustaining education is based on the idea that underrepresented students' cultural and linguistic practices are assets rather than deficits or barriers to the learning process.

Grounding STEM Instruction in Students' Lives

Several scholars (Carlone & Johnson, 2012; Seiler, 2013; Warren, Ballenger, Ogonowski, Rosebery, & Hudicourt-Barnes, 2001) have challenged the metaphor of "bridges" because this metaphor implies that STEM cultures and underrepresented students' cultures are two distinct, bounded, and concretized entities. Instead, these scholars have theorized STEM cultural practices as porous, emerging, and overlapping.

Educational researchers have used alternative metaphors or constructs to describe this porous view of culture. Popular metaphors include:

- **community cultural wealth** (Yosso, 2005),
- **cultural modeling** (Lee, 2001),
- **funds of knowledge** (Moll, Amanti, Neff, & González, 1992),
- **third space** (Gutiérrez, 2008),
- **traditional ecological knowledge (**Pierotti, 2011).

Community Cultural Wealth: Yosso (2005) draws from critical race theory to position community cultural wealth as a counter-point to Bourdieu's (1986) theory of capital. Whereas Bourdieu describes the forms of capital held by dominant groups, Yosso asserts that community cultural wealth "focuses on and learns from the array of cultural knowledge, skills, abilities, and contacts possessed by socially marginalized groups that often go unrecognized and unacknowledged" (p. 76). These forms of capital are resources that can motivate underrepresented students to persist in STEM pathways (Samuelsen & Litzler, 2016).

Cultural Modeling: According to Lee (2007), the Cultural Modeling Project "is a framework for the design of learning environments that examines what youth know from everyday settings to support specific subject matter learning" (p. 15). Students analyze "cultural data sets," or familiar artifacts about which students feel some sense of expertise and ownership, and they discuss how these data sets relate to specific academic discourses, such as those used in science. Gutiérrez, Morales, and Martinez (2009) stated that this metaphor is different from *funds of knowledge* because it highlights students' repertoires of practice rather than adult or family practices.

Funds of Knowledge: Like scholars of cultural modeling (e.g., Ares, 2011; Orellena & Reynolds, 2008), scholars of funds of knowledge often describe how students' cultural practices map onto academic practices (Rodriguez, 2013). González, Moll, and Amanti (2005) defined funds of knowledge as "historically accumulated and culturally developed bodies of knowledge and skills essential for household or individual functioning and well-being" (p. 72; cf. Vélez-Ibáñez & Greenberg, 1992). Historically marginalized students possess STEM-related funds of knowledge that can serve as the starting point for relevant and motivating STEM instruction (Moll et al., 1992; Barton & Tan, 2009).

Third Space: Drawing from the work of Bhabha (1994) and Soja (1996) in their study of Latina/o youths' science-related funds of knowledge, Moje and colleagues (Moje et al., 2004) defined the goal of third space as one that "brings the texts framed by everyday Discourses and knowledges into classrooms in ways that challenge, destabilize, and ultimately, expand the literacy practices that are typically valued in school and in the everyday world" (p. 44). In other words, third space brings together the "spaces" of students' everyday lives worlds and the formal "spaces" of STEM to create a new, hybridized space that incorporates, expands, and challenges aspects the practices, values, and bodies of knowledge in both spaces (cf. Wallace, 2004). Third space includes pedagogical, physical, and political dimensions (Barton & Tan, 2009).

Traditional Ecological Knowledge: Berkes and colleagues (Berkes, Colding, & Folke, 2000) defined Traditional Ecological Knowledge as "a cumulative body of knowledge, practice, and belief, evolving by adaptive processes and handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (p. 1252). TEK-centered science units have been used by practitioners and researchers (e.g., Kimmerer, 2012) to increase indigenous youths' motivation to learn science.

Examples of Applications of CRE in Mathematics

• Students choose topics for inquiry that are interesting to them, and they use mathematical analyses to effect changes in their communities, such as through relocating local liquor stores that are close to their schools (Tate, 1995).

• Students solve mathematical problems that are connected to their lives and their communities (Ensign, 2003; Razfar, 2012).

• Students participate in collaborative family projects with a focus on real-life applications, such as construction work (Civil, 2002) or gardening (Civil & Khan, 2001).

• Students use mathematical analyses to examine societal inequalities, such as racial profiling during traffic stops (Gutstein, 2003).

Examples of Applications of CRE in Science

• Students use scientific principles to analyze and address social injustices such as local water pollution (Dimick, 2012).

• Students make connections between traditional cultural practices, such as arrow making and throwing, and science content, such as accelerated motion (Grimberg & Gummer, 2013).

• Students generate their own lines of scientific inquiry, which are combined with authentic models of scientific inquiry (Buxton, 2006).

• Students explicitly identify how their linguistic and cultural experiences and values relate to those of science via instructional congruence (Lee & Fradd, 1998). For instance, they may discuss how the validity of knowledge claims varies from context to context (Lee & Buxton, 2013).

Examples of CRE in Technology and Engineering

• Students make connections between practices outside of school—such as organizing labor, time, and food for a family-run food stand—and engineering design practices, such as maximizing efficiency (Wilson-Lopez, Mejia, Hasbún, & Kasun, 2016).

• Students learn from respected adults in their communities (e.g., tribal elders). These adults introduce them to traditional ways of designing solutions to local problems, and students use new or traditional tools and approaches to develop solutions to similar problems (Kern, Howard, Brasch, Fiedler, & Cadwell, 2015).

• Students draw from their community cultural wealth, including the desire to help their families and their communities and the willingness to address oppressive structures, in order to persist in engineering programs (Samuelson & Litzler, 2016).

Key Questions or Issues

1. What new or existing metaphors, theoretical frameworks, or research methodologies are likely to advance knowledge in the field of culturally responsive STEM education?
2. Culturally responsive education is a potentially transformative approach to broadening participation in STEM fields. What partnerships, infrastructures, research instruments, or dissemination venues need to be created in order to scale up culturally responsive education and achieve broader impacts at a national level?
3. Aronson and Laughter asserted that, in order to prevent culturally relevant research from being marginalized, "there is a clear need for evidence-based research that documents connections between culturally responsive pedagogy and student outcomes" (p. 164) in ways that speak to policy makers. Although many assessments exist to measure academic skills and concepts, how should (and should) critical reflection, cultural competence, and critique of discourses of power be measured?
4. What are the next steps for research and practice in culturally responsive science, technology, engineering, or mathematics education?
5. What questions, perennial problems, or insights do you have in regards to your work in culturally responsive STEM education?

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