From Responsive Teaching Toward Developing Culturally and Linguistically Sustaining Science Teaching Practices

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Focusing on social and restorative justice means we must challenge current notions and enactments of culturally responsive science teaching that focus on deepening engagement and broadening participation for culturally and linguistically marginalized students. These approaches are necessary but insufficient as we also need a critical perspective to address historical wrongs in science and school and to move beyond a conceptualization of equity as simply issues of access, opportunity, and achievement (Calvaresi, Barton, and Tan 2020). This means interrogating the ways that European science has made many advances, Black, Indigenous, and people of color (BIPOC) have been actively harmed in doing so and scientific industries and school systems have failed to uplift science done by and for BIPOC. Importantly, this science contributes diverse perspectives of hope and possibilities and helps sustain communities of color. Beyond addressing the moral and ethical demands of righting current and historic wrongs, a socially just approach to science education fosters the production of stronger scientific learning and ultimately stronger science through the integration of truly diverse questions, approaches, and resources. With a broadened view of the discipline and how scientific knowledge has been and could be constructed, educators can reshape a new science that sustains non-dominant community cultures and ways of being, creating a pluralistic society (Paris and Allen 2014).

We propose a four-part framework for Critical and Cultural approaches to Ambitious Science Teaching, CAST, to support educators in grounding learning opportunities in students’ cultures and identities and work toward culturally and linguistically sustaining practices. We build on our previous work with Ambitious Science Teaching, which emphasizes valuing students’ ideas and anchoring science units in real-world phenomena (Windschitl, Thompson, and Braaten 2018), and offer a critical equity perspective for teachers to consider issues of power, identity, and the sociopolitical context (Gutiérrez 2002).

For each principle, we begin with a vignette, unpack central ideas, and suggest culturally and linguistically sustaining tips as starting places for science educators.

Principle 1: Recognizing our own and other’s worlds and developing critical consciousness

Ms. Colley raised a blow-horn in the middle of a playground as students and other students at different distances tried to reach decibles. Everyone paused as an airplane flew over and landed as a nearby airport. One student exclaimed, “I hate airplanes. They wake me up every night.” Other students chimed in with stories of other ways that this airport affected them. As teachers, we met after class and decided that the overarching puzzling phenomenon about a singer-shattering a wine glass with his voice was insufficient. We researched the phenomenon and discovered they were 25 years old and decided to develop a complementary activity and to support student inquiry in writing to city and airport officials about the realities of noise pollution. Yet, many of us did not confront our own privilege as we drove home to a quieter part of town.

While the teachers responded to a problem that students raised, we needed to do more to examine our own positionalities, issues of power, and privilege prior to action. Upon reflection, we offer these suggestions to brighten teacher awareness: When students use passionate language (e.g., I hate airplanes), pause and ask: How can I learn more about my students’ experiences? How can I be responsive to my students’ context? If I am experiencing cognitive dissonance (e.g., I don’t feel as strongly as my students), ask: How can I check my own assumptions and examine how my privilege and power are a part of this situation?

The first principle in the CAST framework addresses critical consciousness as an understanding of one’s own positionalities and biases. Because many teachers grew up learning science in unjust and racialized contexts and have not been positioned to question these perspectives, teachers need experiences that challenge eurocentrism so they can shape new visions of teaching and learning science that will be more inclusive of students’ rich linguistic, racial, and cultural resources. Tip 1: Find critical colleagues. Start a book club and read critical literature (e.g., DiAngelo’s White Fragility (2018), Kendi’s How To Be An Antiracist (2019), or So You Want To Talk About Race by Clark (2019), and Abolitionist Teaching Network https://abolitionistteachingnetwork.org/), and brainstorm how to decenter whiteness in upcoming lessons. Examine the culture of power (Delpit 1988), the socio-historical context and how it shapes school and science learning (Beng et al. 2012), the importance of moving beyond equity as technocratic (Calubrac Barton and Tan 2020), and the typical “equitydetours” (González 2019).

Simultaneously, engage in self-reflection to understand one’s own narratives about race, class, language, and culture and question the dominant narratives that are often portrayed in science learning. Tip 2: Write a K-12 autobiography. Reflect on the ways in which you experienced continuity (or not) among home and school and write a self-narrative about cultural and linguistic (dis)connectedness, identity, access, and power in science school (Costa 1995; Peshkin, Davidson, and Cao 1991). Frequently revisiting these narratives, in light of experiences in classrooms and additional readings, can help broaden one’s perspective about privilege, power, and students’ capabilities (Villegas and Lucas 2007).

Principle 2: Learning about and prioritizing students’ communities and cultures

Youth, seasonal farm workers, school board members, and other community stakeholders worked with teachers to bring awareness and problems that matter to their hometown. In the midst of the conversation, one youth asked, “Why do grocery stores strawberry taste chemically?” She explained that the fruit from the store doesn’t taste the same as what they grew. Pursuing this question, a teacher called an organizer at a local farmers market,
which led to a summer of collaboration among farmers, teachers, youth, and community members. They designed a weeklong summer camp where youth engaged in farming, selective breeding, soil sampling, and analysis in the different fields of their community partner. Situating science in the community in which students lived served to invigorate youth to share their love of science through their community and others whose educational needs they addressed. The science curriculum was based on soil composition and testing, the phenomenon driving the study was a student's question. Situating science in a local issue prioritized places, people, and languages that were familiar to youth. Moreover, youth developed critical science identities as they participated in and were recognized by themselves and others as science doers and thinkers. The second principle of the CAST framework intentionally situates science learning in service of the plurality of youths' cultural identities. Cultural membership is different for each person; teachers have a responsibility to seek to understand what various cultural memberships mean for particular students. Knowing what it valued in a community offers a lens into and connections with local culture. Tip 1: Create an asset map of local resources related to the upcoming units you are teaching (see Figure 2). The map can include physical assets such as buildings, economic assets such as beauty shops, institutional assets such as churches, and human assets including stories from newspapers or grandparents. Consider constructing this map with community-based organizations or parents. Beyond connecting to these assets, science education can serve to positively influence and intentionally sustain aspects of local culture by positioning students as people who can immediately use their knowledge to learn in or celebrate local ways of knowing or doing. Tip 2: Do a community needs assessment. Listening to and learning from community stakeholders can reveal problems that provide an authentic need and audience for science learning. Yet, not all aspects of youth's cultural identities are as obvious. The youth from the vantage point of a tradition of drinking water from a nearby drainage ditch before sporting events. Teachers invited youth to use science to critique local culture, using water quality findings to justify a needed change in practice. Tip 3: Include critical conversations as a core of classroom culture. Include topics in your classes that help students examine their own and other's experiences (i.e., with vaccines or access to clean water) and the ways in which stakeholders have failed to consider multiple perspectives.

Principle 3: Designing for each student's full participation in the culture of science

"We are a group of teams taking a stand for the lake next door. We are investigating the health of Hocking Lake and hope to get others involved. In the 1960s it was a swimming hole. Over the years it has become a dump and the lake has become eutrophic. We want to clean it for fish and animals to enjoy it. A group of middle and high school young women participating in an after-school program said their wish was to open their film to raise awareness about a toxic lake by their school. For months they conducted experiments, interviewed community members and scientists, revised working models of the biochemical processes, and developed a film. They opted to use stop-animation as a youth-friendly way to tell the story of how the lake becomes toxic each spring and is dangerous for domestic animals and wildlife, and how scientists and community members are trying to revitalize the lake using islands with floating plants to remove excess phosphorus. The film closed with the young women talking in their home languages (Spanish, Arabic, and Somali) to family and community members about what they learned about themselves. Films: https://scicenter.com/92776664

These young women fully participated in science as they enacted their multiple identities as scientists, activists, and family members and sought to take action in their own community (Labhmann 2016). Developing the film allowed them to share their research using their languages, identities, and local experiences as sensitizing repertoires.

The third principle in the CAST framework catalyzes creating opportunities for students to fully participate in school science in ways that honor and leverage cultural and linguistic identities and sensitizing practices. Phenomenon-based learning, such as investigating how to clean up a toxic lake next to the school, allows students and teachers to interact directly with the natural world and invites collaborative and diverse sensitizing. Tip 1: Involve students in the design of phenomenon-based curriculum and co-create shared experiences in the classroom. Involving students in the design of the unit and open-ended investigations into real-world phenomena (such as designing experiments with lake water samples and creating a stop-animation film) shifts power structures in the classroom and creates opportunities for students to share their expertise and learn from others.

Designing for students to fully participate in scientific sensitizing also requires that teachers center students' multilingual and multi-literate ways of knowing. Research in the workspaces of scientists shows that they use multiple languages, gestures, and narrative language to communicate ideas. Tip 2: Provide students' broad sensitizing repertoire. Invite students to use translanguaging (Suárez 2018) as productive sensitizing in classrooms; challenge students to think about how they use language in science; and avoid front-loading vocabulary, which sends the message that there is "a right way" to use language in science classrooms (Suárez et al. 2019). Along with this shift in pedagogy, teachers can challenge their own perceptions of how science should look and sound, and strive to unlearn ideologies that are Eurocentric and monolithic.

Images from STARS (Students Tackling Authentic and Relevant Science) stop-animation film and prototypes of signs the young women developed to inform the public.
**An equity noticing tool for examining students' scientific ideas inspired by Patterson Williams, Higgs and Athanases 2019.**

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<td>Students' ideas are scientific. What do students already understand about the phenomenon?</td>
<td>What everyday language did students use? How did students use multiple languages or different narrative forms? How were they representing key ideas without words (i.e., gestures, use of color in work)?</td>
<td>How are students showing/writing about race, power and justice (including justice for animals and the environment)? How did students talk about their own agency, such as how they could/will take action in the world?</td>
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**Principle 4: Challenging the culture of science through social and restorative justice**

In high school Biology, students modeled HeLa cells and how cervical cancer cells continuously divide. Simultaneously, for Language Arts they read Rebecca Skloot’s The Immortal Life of Henrietta Lacks and learned evidence-based claims about the historical issue of scientists taking cells without consent. They read legal codes, discussed injustices, and studied how Lacks’ family fought to raise awareness. On a culminating assignment, one student reflected, “Although scientists have made many breakthroughs with her cells, they don’t give much importance to the woman who provided them the key to their research. It is surprising the family has not been given anything for their mother’s cells despite the fact that they did not give permission to take the cells. The court has given scientists the right to exploit a patient's tissue for their economic benefit and failed to recognize where the tissue came from. I can't imagine the mixture of feelings the family must have, their mother's cells changed history.”

The teachers provided students with the opportunity to analyze the harmful impact of bias and injustices, engage in conversations about actions that would repair this harm, and examine institutional injustices. Yet they did so in a way that emphasized stories of empowerment and justice, not damage and deficit-centered narratives. Engaging students in these conversations provides opportunities for students to critique and challenge the culture of science and work collaboratively to create change.

The fourth principle of the C'AST framework recognizes that social justice calls for prejudice reduction and collective action (Teaching Tolerance, 2018). Students need to question and challenge myths about “science as truth,” critique Eurocentric science as a dominant way of knowing and engage a heterogeneity of ideas and multiple ways of knowing. Tip 1: Analyze classroom culture. Invite students to examine the culture of the science classroom, including connections, and ask about experienced marginalization. Teachers can support students in this challenging work by using Color Brave Safe Principles (Schillinger and Okuoro 2017) to attend to racial equity and the concept of Interpersonal Safety (Jackson 2001) to cultivate collaborative civic spaces (Makaiwa 2019). This will help students feel emotionally and intellectually secure to ask questions and state multiple and sometimes opposing views. What develops out of this is trust, the courage to present one’s own views, and opportunities to practice democracy.

Principles from restorative justice—the idea that we must create just and equitable learning environments, avoid punishments, nurture healthy relationships, repair harms, and transform conflict (Watn 2013)—can address the disengagement of students. Tip 2: Learn about talk circles. Read about and implement talk circles as a way to address serious classroom matters, including conversations about harms and injustices (Blumh 2016).

As graduates of unjust school systems, injustices as well as stories of bravery can be difficult to see. Tip 3: Get involved. Participate in community-based civic engagement activities and read about social justice projects. Identify the knowledge, inquiry skills, and dispositions needed to procure justice.

**Conclusion**

As science classrooms are becoming increasingly diverse—linguistically, racially, and socioeconomically—science instruction needs to support the honoring and continued strengthening of students’ varied identities (NIECE, 2012). We have found it useful to approach the discipline with humility toward the relative im...
portance of scientific achievements; as such science teachers can nurture the plurality, diversity, and generative nature of culture that is both beautiful and necessary for global citizenship. Our hope is that the C’AST framework offers a starting point for educators to create learning environments that develop students’ identities as learners, scientists, and publicly engaged citizens. We encourage teachers to develop professional learning communities and use the framework, resources, and self-assessment and planning questions (see Table 1) to get started on this critical work. Our sense is that self-assessment and planning are reciprocal processes and that teachers will return to self-assessment during the planning process and after teaching.

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