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Commentary: Designing Science Instructional Materials that Contribute to More Just, Equitable, and Culturally Thriving Learning and Teaching in Science Education

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Introduction

The *Framework for K-12 Science Education* (National Research Council, 2012) and the Next Generation Science Standards (NGSS Lead States, 2013) represent a vision of equity for science and engineering learning. Each of the papers in this issue points to equity as a key dimension in realizing the vision of the *Framework* and NGSS when designing instructional materials. Across the set, equity is used in various ways and for various ends. For example, Miller et al. (this issue) draw on Ladson-Billings (1995) tenets of culturally relevant pedagogy for curriculum design that is responsive to students' ideas. Edelson et al. (in this issue) position equity as enacted by the teacher through leveraging students' funds of knowledge (Moll et al., 2005). For Reiser et al. (this issue), equity is enacted through routines that work to ensure epistemic agency in classrooms and by intentionally selecting storyline contexts that are interesting to minoritized youth. For Haas et al. (this issue), equity is enacted through place- and project-based approaches to science learning and through attention to theories of second language acquisition.

The purpose of this commentary is to offer a perspective on how the ambitious and important work in this special issue can be even more explicit about centering equity and push toward justice-centered goals in science education. In what follows, we present a framework for gaining clarity and specificity on the concept of equity and explore how conceptions of equity in the papers in this special issue map onto that framework. Next, we discuss design features of science instructional materials that build toward conceptions of equity that center justice-oriented goals. Lastly, we present some of what we are learning in our own work related to the full complement of conceptions of equity explicated in the framework.

Conceptions of equity through four discourses

Science learning settings (e.g., schools, museums, parks) are not sociopolitically neutral spaces and are thus imbued with historicity and power, especially in the ways that they make (in)visible policies, practices, and programs that limit access or opportunities to learn for nondominant youth and their families. Philip and Azevedo (2017) argue that

“the very conception of equity in the field is a moving target,” leading to both “conceptual and theoretical imprecisions” (p. 526) that may inadvertently end up preserving the very systems we mean to dismantle. They argue that in the *Framework* (National Research Council, 2012), equity is framed in ways that (1) “simply diversify the actors in certain privileged segments of an otherwise enduringly inequitable and unjust society” (p. 526), (2) equate equity with equality—that is, equity as fairness and equal treatment, and (3) relegate injustice to the past, rather than pulling past injustices into the present and situating them within ongoing systemic processes. All of these approaches to equity, Philip and Azevedo argue, do “preserve the status quo . . . they simply diversify the actors in certain privileged segments of an otherwise enduringly inequitable and unjust society” (p. 526). Leaving discourses of equity invisible, unquestioned, and/or unpacked can contribute to the perpetuation of inequity, sometimes making it appear as if science is learned either in a social vacuum or in neutral contexts. The ways in which learners experience science in learning spaces are intimately tied with our efforts to address (or not) institutional forms of oppression.

In an effort to articulate approaches to equity and push against the “politically diminished and inadequately historicized meanings of equity” that pervade both the language of equity in the *Framework* (National Research Council, 2012) and scholarship in science education more broadly, Philip and Azevedo (2017) seek to bring more precision and power to the concept. To that end, they outline four *discourses of equity* that are present in the science education literature: (1) *improving students’ achievement, access, and inclusion* in school science by “fostering connections to classroom disciplines and promoting personal relevance” (p. 528), (2) *increasing students’ interest in and identity with science*, (3) *broadening what counts as science* by making visible the “diverse ideologies and epistemologies in everyday science practices” (p. 529) that push on privileged forms of science, and (4) *exploring the intersection of science with social movements* toward social transformation and justice.

We see traces of each discourse across the set of papers, with more attention to Discourses 1 and 2 and less on 3 and 4 (a pattern which is also reflected in the larger science education literature). All of the papers point to the need to promote personal relevance (Discourse 1), through storyline contexts (Edelson et al., this issue; Reiser et al., this issue) or connection to place (Miller et al., this issue; Haas et al., this issue). Haas et al. (this issue) also emphasize the need to make science more accessible for multilingual learners by centering modalities, registers, and interactions. Increasing science-related interests and identity (Discourse 2) can stem from students seeing their own questions driving the progression of a storyline (Reiser et al., this issue), students seeing their own neighborhoods, communities, and practices represented in the curriculum (Miller et al., this issue; Haas et al., this issue), or students having the opportunity to engage with broader representations of scientists of color in equity-focused lessons (Miller et al., this issue). Broadening what “counts” as science (Discourse 3) can be accomplished when a teacher recognizes the diverse sensemaking of students during discussions and debate (Reiser et al., this issue), or when teachers use family interviews to elicit family sensemaking around a topic (Miller et al., this issue). Finally, science intersects with social movements toward justice (Discourse 4) when students engage in critical map-reading, for example, to understand biodiversity in “wealthy and poor international urban areas” (Miller et al., this issue).

There are, however, potential pitfalls to the approaches to equity represented in each of the papers. The discourses presented by Philip and Azevedo (2017) are part of larger systems of power at the classroom, school, political, and professional levels. For example, finding “motivating” contexts or problems to help situate storylines without addressing multiple ways of knowing (Warren et al., 2020) does little to de-settle the privileged epistemological, ontological, or axiological dimensions of Western science (Bang et al., 2012). In fact, there can be the tendency to separate “cultural” or “equity-focused” lessons and “science” lessons, thus reifying dominant Western discourses that hold science as acultural, ahistorical, apolitical, and/or neutral. Making space for epistemological, ontological, and axiological diversity in science (Discourse 3) requires that teachers are attuned to seeing sensemaking as culturally, ethically, and politically laden and that teachers are adept at incorporating those forms of sensemaking into learning environments productively (Rosebery et al., 2016). Moreover, connecting to larger social justice movements (Discourse 4) must accompany a change in relational quality among classrooms, schools, families, and communities. If dominant compliance models of family and community engagement are still in place (Ishimaru, 2019; Learning in Places Collaborative, 2021), science learning will not be authentically connected to community-based issues in ethical ways.

Designing toward equitable instructional materials for science education

Science instructional materials wield enormous power in educational settings. They are part of the structures and narratives of school science, helping to codify what science learning and teaching look, sound, and feel like, as well as what messages about scientific disciplines get engaged and disseminated, including who and what counts as legitimate within the sciences. Science instructional materials are steeped in historicity—their structures and affiliated tools, practices, and content have histories that are powered and shape and perpetuate narratives about what school science is and how science learning and teaching are done. To design equitable science instructional materials, it is critical that design teams pay deep attention to power and historicity, and to cultivating models of family and community engagement for ethical relations to powerfully support learning. We locate power in structures and systems, and as related to individuals with respect to their identities, their relationships with others, their agency, and their positionality in any given context. We use historicity to mean “cultural perceptions of the past, the principles, experiences, and values that shape these perceptions, and how historicized practices, tools, and information continually and consequently shape the present and future” (Learning in Places Collaborative, 2021).

It is imperative to pay attention to the processes, substance, and implementation of design because who is at the design table matters for the extent to and the way in which Philip and Azevedo’s (2017) four equity discourses are addressed and how teachers are supported in implementing instructional materials that embody these four equity discourses. Edelson et al. (this issue) argue that “decisions about who participates in the design and development of instructional materials and how they participate can have as big an impact on the product as any other design or development decisions” (p. 783). To that end, the OpenSciEd project has intentionally utilized a wide net of diverse stakeholder groups in iterative design and development processes, including state-level education leaders, teachers, and students. Similarly, Haas et al. (this issue) argue for teachers as co-designers, along with linguists and other NGSS writers in their design team. They work to

intentionally identify students' funds of knowledge and how those might be connected to anchoring phenomena in their instructional units.

All of the papers acknowledge the heavy lift that NGSS-aligned, equity-focused science instruction represents for teachers. Reiser et al. (this issue) raise the concern that, even with supports for problematizing students' models and inviting a diversity of ideas into the classroom, teachers need to both recognize and "leverage" that diversity in productive ways in their instruction in order to move toward Philip and Azevedo's (2017) Discourse 2. Like Edelson et al. (this issue), they argue that while teachers can draw on designed supports in instructional materials, instructional materials are not sufficient for supporting the types of pedagogical and axiological change called for in equity-centered instruction that is aligned to the NGSS. As illustrated in the work done by the teacher professional learning communities in Miller et al. (this issue), driving questions, even when designed to be broadly relevant to students, still require work by the teacher to be culturally responsive to students' families and communities (Discourse 2).

While increasing representation of who is at the design table is necessary, it is not sufficient for grappling with fundamental powered relationships in science and in science education—the "how they participate" aspect of the design team (Edelson et al., this issue). One way that these papers could go further in moving toward Philip and Azevedo's (2017) Discourses 3 and 4 would be to describe strategies for how design teams explicitly grappled or could grapple with issues of equity and inequity in both typical classroom and school systems. For example, schools often employ compliance models, which are steeped in deficit frames of families, especially those families who identify as members of minoritized communities for whom educational institutions have been places of oppression, erasure, and cultural violence (Learning in Places Collaborative, 2021). In order for instructional materials to be tools that mediate more just relational dynamics among families, communities, and schools, design teams need to first acknowledge these compliance frames and then design both materials and relationships to move toward more equitable frames that support student learning.

Discourses of equity tend to describe injustices as happening in the past rather than as ongoing, historicized processes. Therefore, another way these papers could go further in moving toward Philip and Azevedo's (2017) Discourses 3 and 4 would be to address power and historicity directly. However, design teams need to first grapple with how their own classroom design and pedagogical practices contribute to ongoing inequities before they can make those visible within instructional materials themselves. Instructional materials can help teachers recognize that science, science learning, and the places in which these activities occur are steeped in historicized patterns of racialized oppression and erasure. Design teams need to first be aware of how their own historicized patterns of racial oppression and erasure show up in their work, as these are often invisible and steeped in whiteness, as well as the systems that support whiteness (Vakil et al., 2016). This is where iterative processes of design and research, as described in Miller et al. (this issue), are valuable in surfacing problematic practices. The research team came to understand the ways in which teachers supported each other in centering cultural knowledge and practices of home and community and then enacted those in the design of teacher materials. For example, within the context of professional learning communities, teachers strategized about how to make driving questions more culturally responsive, bringing in experiences from immigrant families and broadening whose voices were heard in the classroom.

Toward transformative designs: lessons from learning in places

In this section, we offer some specific design features we used in our own work that make visible dimensions of equity to move toward Discourses 3 and 4 from Philip and Azevedo (2017).

Ethical deliberation and decision-making

In Learning in Places, the move toward socially just science teaching and learning (Discourse 4) involves a fundamental examination of humans' relationship to the natural world. Making choices about what questions to ask, which data to collect, and when and how to intervene in natural processes are all decisions that are steeped in nature-culture relations that position humans as either apart from and superior to the natural world or as part of and equal to the more-than-human world. "Ethical decision making requires that we ... carefully consider how powered dynamics and historicity shape socio-ecological phenomena as well as our decisions, and the impacts our decisions will have for different peoples and places. Decision making that fails to do this enables the perpetuation of unjust systems" (Learning in Places Collaborative, 2021). In our work, this takes the form of "Should We" questions that drive the progression through a storyline. Asking questions such as: *Should we move earthworms from the sidewalk? Should we put rat traps around our school? Should we remove invasive ivy from our school's wetlands? Should we attract more "wild" animals to our school's park?* requires investigations into ecosystem dynamics and relationships, community-based data collection, continuous deliberation using data and attention to histories of places, and learning that "Should We" questions do not have straight-forward answers. We have designed an ethical deliberation and decision-making framework that incorporates critical ideas of place, family/community values, data analysis, and power and historicity to support students, families, and teachers in engaging in ethical deliberation and decision-making toward living in just relations with each other and the natural world (Discourse 4).

Design of instructional materials

Educative curriculum materials are a powerful tool for teacher learning and instructional shifts (e.g., Davis & Krajcik, 2005). In our instructional materials, we use typical "callouts," such as assessment opportunities and connections to science and engineering practices, and we also routinize explicit callouts related to connections to family and community ideas and ways to support justice-centered practices (Discourse 4). For example, in our efforts to make visible historicized ways that dominant discourses of Western science teaching invisibilize Indigenous peoples and their ways of knowing, one callout says, "'De-settle' your own ideas about place and Indigenous peoples: History is often taught in a way that (1) completely invisibilizes Indigenous peoples, (2) romanticizes relationships between Indigenous peoples and settlers, and/or (3) makes it seem as if Indigenous peoples no longer exist. Educate yourself about what Indigenous lands your school sits on, which Indigenous nations are your school's neighbors, and how Indigenous practices influence the places, science, and stories of the places where you live and work." (Learning in Places Collaborative, 2021).



Educator frameworks

The move toward the kinds of equity-centered pedagogy called for across the papers in this issue requires deep paradigm shifts for teachers and designers. For example, centering power and historicity in science instruction means recognizing the ways that schooling, discussion norms, and even the language we use to describe nature have been used to institutionalize human supremacy over nature and settler colonial aims (e.g., Bang et al., 2012). To that end, we have developed a set of educator frameworks that orient educators to foundational dimensions of equity-focused and anti-racist science teaching, such as power and historicity, culture, learning, identity, nature-culture relations, family and community engagement, and histories of places (Discourses 3 and 4). Each framework includes vignettes showcasing the ideas in practice, specific question-asking, discussion, and scaffolding strategies for engaging students with the ideas in practice, and educator self-assessments that make visible important dimensions of practice for reflection and goal-setting. These can be used as the basis for professional development or teacher self-study to shift teacher practice toward justice-centered ends.

Closing thoughts

Science instructional materials aligned with the *Framework* (National Research Council, 2012) and NGSS have the power to transform science learning and teaching, especially when accompanied with professional development and educative curricular supports. However, science learning toward Discourses 3 and 4 from Philip and Azevedo's (2017) framework—just, sustainable, and culturally thriving communities—requires paradigm shifts. All of the papers in this issue recognize the enormous task that this type of paradigm shift will require of teachers, designers, and school systems. To that end, it is critical that designers of instructional materials think systemically about how scientific enterprises and science learning and teaching intersect with historicized inequities that have limited access, denied opportunities, erased, and otherwise marginalized and oppressed multiple groups of learners, their families, and their communities. Deep shifts toward equity will ultimately require that those working at the intersections of design and teacher and student learning make visible the power and historicity of the systems we are working within, which will require examinations of our design processes, collaboration practices, products, and underlying ideologies.

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