

Designing Science Curricula that Disrupt Disciplinary Boundaries Towards Sociopolitical Change: A Middle School Life Science Unit

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Abstract: Supporting minoritized students' participation in a science requires designing expansive notions of what counts as doing and learning science. We present the design of a middle-school biology unit about stress and body system interactions that challenges the boundaries of disciplined science and promoting social change making through consequential learning. Four core axiological commitments shaped the design of the unit: a) expanding disciplinary practice by entangling mind, body, and environment; b) supporting students' rightful participation and expertise; c) recognizing the environment as politicized across scales; and d) supporting social change through allied political struggle. We describe how we embodied these commitments in the unit design and how they played out in the context of a 7th grade urban science classroom. This work provides another example of consequential learning environments and contributes to the theory and practice underlying their design.

Introduction

Over the past two decades Learning Sciences has increasingly attended to issues of equity and justice by recognizing that all learning environments are inherently political and thereby serve to either maintain the status quo and (re)produce inequities or disrupt historical and ongoing injustices and redress them (Esmonde & Booker, 2017). In the context of science education there have been ongoing efforts to promote a more expansive view of desirable aims that include using science to identify, investigate, and address injustices (Basu et al., 2009; Morales-Doyle, 2017). Such efforts have emphasized the importance of learning that is consequential to students in that allows them to participate in science through knowledge and practices that are relevant and meaningful to them and their communities (Tan et al., 2019). Designing for consequential learning therefore entails attending to and disrupting settled and powered participation structures in order to expand disciplinary boundaries (what counts as science) and allow for new aims and new forms of participation. A core and valued aim of consequential learning is to make visible and address locally meaningful injustices that are, invariably, rooted in broader sociopolitical injustices (Tan et al., 2019).

In consequential learning environments legitimate participation extends beyond being included and supported in sanctioned disciplinary practices and entails rightful presence-- the ability to reauthor rights, make injustices visible, and shift normative power relations and expectations. The *Rightful Presence* framework (Calabrese Barton & Tan, 2020) challenges traditional notions of equity as inclusivity and argues that legitimate participation needs to afford changing those very rules and expectations by challenging guest-host powered relations. Traditionally, students in science classrooms function as guests learning new normative disciplined practices (ways of doing, being, knowing) from the teacher or adult hosts. Given the (still) prevailing view of science practice as relevant to yet unaffected by broader social and political struggles, students' own experiences of historical and ongoing injustices are not made visible as part of science learning nor made welcome in the classroom. Rightful presence therefore entails making sociopolitical struggles visible in the classrooms as a legitimate form of participating in science, and places responsibility on those who hold power in these spaces (e.g., teachers) to leverage their positions, as sociopolitical allies, for change towards more just outcomes.

Examples of consequential learning environments in K-12 science education, while compelling, are rare and the field would benefit from additional efforts (National Academies of Science, Engineering, and Medicine, 2022). Here we discuss the design of a middle school life science unit aimed at addressing science standards in the U.S. (NGSS Lead States, 2013), while also challenging the boundaries of disciplined science, and promoting

social change making through consequential learning. Our aim with the unit was to address science standards through investigation of a health issue that was of concern to the local community through a unit that involved sociopolitical change making at the local level. This design work was guided by commitments to and intentional design towards: a) expanding disciplinary practice by entangling mind, body, and environment; b) supporting students' rightful participation and expertise; c) politicizing the environment across sociopolitical levels (national to local); and d) supporting social change through allied political struggle.

We present a middle school biology unit-- Bio4Community: *Stressed Out- How our bodies interact with our environments*, as a design case with the hope that it can contribute to the field in three ways. First, as an example of expanding disciplinary practice in the context of life science adding to the small, but growing, collection of exemplars of consequential and justice-oriented science units available for researchers and practitioners. Second, as an example of connecting structural oppressions at the larger sociopolitical level to their local manifestations. Third, and following from the prior point, as an example of student-developed solutions that are, in turn, aimed at transforming inequitable structures and policies at the local level (but that are embedded in the larger sociopolitical context) in ways that will benefit their community.

The Bio4Community design team and the Stressed Out! unit

Our team was engaged with design in multiple configurations, some of which included youth and teachers from the school district with which we collaborated (Krishnamoorthy et. al., 2021). As a research team we hold different positionalities (in terms of racialized and gendered identities, ethnic backgrounds, and their intersections), we have different lived experiences and expertise. Team members also brought experiences and perspectives informed through their identities as immigrants (voluntary and involuntary), settlers on colonized lands, and as members of the queer community. The collaborating teachers who enacted the unit were a Middle-Eastern immigrant woman who has been teaching in the urban district for multiple years and a Black woman who recently joined as a special education teacher in the 7th grade classroom and also had extensive experience teaching in urban and marginalized settings. This district itself serves a majority Hispanic community (85%) with over two thirds of families socioeconomically deprived.

Briefly, the unit included six lesson sets each lasting multiple days. The first lesson set introduced students to the phenomenon of stress grounded in their embodied experiences, through testimony from community members their age, and through quantitative data from their community. In the second lesson students engaged in community ethnography and developed a survey about causes of and solutions to stress in their community. The survey was sent out to the school community. Results from the survey were analyzed later in the unit to inform students own solutions in the stress-in-our-community problem space. The third lesson set engaged students with evidence from, predominantly, Eurocentric scientific research about the short-term stress response (fight-or-flight) to support the construction of a class consensus model of this phenomenon. In the fourth lesson set students investigated long term stress through a set of stories. The fifth lesson set focused on the ways in which injustices structured into the environment act as ongoing stressors. In the sixth and final lesson set students developed "proposals for change" that honed in on a particular cause of stress in their school (based on analysis of the survey done earlier in the unit), identified the existing structure or policy that was at its root, and advocated for a solution at the policy level (e.g., universal bathroom policy). Students presented these to the principal, faculty, and staff.

Axiological commitment I: Expanding disciplinary practice by entangling mind, body, and environment

Much of school science is grounded Eurocentric ways of knowing that separate humans from the environment and mind from body. In the *Stressed Out* unit we learned from Indigenous scholars by taking a more expansive and holistic view of human biology that focuses on the relations between and within the mind, body, and the MTH (Bang et al., 2012; Kimmerer, 2013). Throughout multiple activities were encouraged to express physiological sensations (heart rate, sweating, shaking) and mental sensations (overthinking, anxious, crying) as entangled, legitimating a holistic view of how we define stress in our bodies.

To engage students in exploring the effects of chronic stress on our minds and bodies we used an approach we term story-driven investigations that presents students with a story that includes evidence and that explicitly weaves the sociopolitical. We endorsed an expansive view of evidence that included community-based knowledge from elders and respected community members (along with normative scientific evidence). For example, one of the stories involved a high school student- María- who struggles to focus in class and is frustrated by this. María's abuela (grandmother) suggests that she may be unable to focus due to stress setting María (and the students) on a journey to find out whether stress can actually affect your focus. Throughout this journey María leverages the expertise of multiple individuals including family, teachers, and scientists who provide her with resources that serve as evidence in her quest for an explanation.

María's story was intentionally designed to entangle feelings, thoughts, and the neuronal networks in the brain with her school and home environment. Taking an adaptive, rather than deficit, view of the impact of stress on the brain, in the story María finds out that stress increases connections in the brain's fear networks making the mind constantly "on alert", and reduces connections in the attention network making it hard to focus on cognitively challenging tasks such as taking a math test. Both sides of this response, are adaptive but in the context of schooling become a problem. Entangling feelings, mind, body, and environment was an intentional decision that was embodied and made explicit in all three stories.

Axiological commitment II: Supporting students' rightful participation and expertise

Throughout the unit students' experiences and expertise served as crucial and valued levers in driving the investigation forward. Students' experiences also served as proxies for the experiences of the larger middle school community and informed community ethnographies. In this sense, students' personal experiences informed theoretical construals of the phenomenon—how stress shows up in the community and what are its causes. The proposals for change (Lesson set 6) that were informed by the community ethnography data also intertwined disciplined science knowledge (model of long term stress) and community knowledge. The legitimated presence of local and personal knowledge shaped the problem space and made salient the importance and relevance of that knowledge; students were able to reauthor what kinds of contributions, problems, and solutions were valued.

In an effort to encourage youths' rightful presence through valuing their worlds as consequential to their learning, all three stories featured family and community members as integral to the main character's sense making journey, such as the positioning of elder wisdom (María's abuela) as culturally relevant (Ladson-Billings, 2021) to and explicitly *not* less important than disciplined science knowledge. As this part of the unit unfolded, abuela's role in youths' sensemaking expanded beyond the words on the page. When explaining their model of "stress and focus" to the class through a skit, the youth prominently featured María and her abuela's relationship as central to the model of long-term stress. Acting as a sociopolitical ally, the teacher (host) ceded power to the students (guests) in authoring their rightful presence in the space through legitimating social interactions in which one student began identifying himself as 'abuela' (and was referred to as such by the teacher). Finally, the consensus model-making activity, was led by 'abuela' (the student), who was called on to evaluate the model. 'Abuela'. The class positioned their consensus model as being storied, by abuela - thus weaving disciplined science with culturally valued expertise (abuela) and practices (story telling).

Axiological commitment III: Politicizing the environment across sociopolitical levels

We wanted students to understand that minoritized communities are not at fault for being stressed, and while they are agentive in their own survival, they do not have much control over the stressors in their environment because those are intentionally structured into the environment. Towards this aim, we interrogated our positionalities and ways of knowing (Austin, 2023) with regard to the disproportionate impacts of white supremacy on our lives. This resulted in a more nuanced presentation to the students of data about perceived stress in their town, disaggregated by race and income level, in the very first lesson set, to position health disparities as ultimately caused by the environment. The stories included many details about the characters' environments in terms of the unjust structures and policies. For example, one of the stories featured Felix and Josue a young gay couple living in a segregated and economically disadvantaged neighborhood with limited access to health facilities and robust grocery stores, yet with a culturally vibrant and supportive community.

We have used the language of unfair structures, policies, and procedures to support students in seeing and naming these elements in the environment. This framing helped us illustrate: a) the designed nature of injustice in the environment (i.e., targeted racial policies such as redlining); b) that these environments are not neutral in that different groups of people experience them differently; and c) that these environments are therefore not benign, they cause inordinate harm to some groups of people. Students then applied what they learned about unjust structures, policies, and procedures at the larger societal level to their own local context—i.e., what structures, policies, and procedures in their school stress them and their community of peers.

Axiological commitment IV: Supporting social change through allied political struggle

Social change making requires understanding and disrupting the structures operating to propagate and entrench inequities. Successful efforts depend on the support and allied struggle of others in the community, and in particular those in positions of privilege and power (Calabrese Barton & Tan, 2020). The teachers, a highly regarded elder in the community, and the researchers worked with and alongside the students in their advocacy efforts. Several curricular activities in the last two lesson sets supported this allied political struggle. First, the teachers and the elder created and shared their life-lines of stress depicting stressful events in their lives from middle school to adulthood, making an effort to explicitly connect the stressors they experienced to unfair

structures and policies. Second, the students interviewed the elder (another form of community ethnography) about her experiences with racism and her sense of unfair structures in the school environment and what has been done about them. The elder shared advocacy and activism efforts she had participated in the school to allow students to wear hoodies. She emphasized the importance of “being right” and doing due diligence on researching and understanding the inequities and their root causes (structurally) and then intentionally developing allyship and support in activism that aims to disrupt them. Third, the principal was invited to the presentation of students’ proposals for change and, in turn, was able to provide the students with an opportunity to present to all the school faculty and staff during a faculty meeting. This was not a trivial opportunity to bring to fruition and required substantial effort on the principal’s part- another example of allyship.

Concluding remarks

Here we have attempted to explicate the axiological commitments undergirding our equity conjectures (Lee et al., 2022). Centrally, we attempted to take an overt political stance by developing materials that engage students with the historical and political nature of the injustices experienced by marginalized communities. Understandings about racism at the broader sociopolitical context were then leveraged to make sense of and advocate against local institutionalized oppressions and inequities as experienced by the students. The science ideas and explanations students’ developed in the unit motivated the urgency and need for the sustainable solutions students proposed. In this sense the disciplined science, local knowledge, and embodied experiences were brought together, consequentially, to problematize and push against the status quo.

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