(W)HOLISTIC SCIENCE PEDAGOGY

Teaching for Justice

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A
ccess to quality science and math instruction remains a civil rights and social justice issue as the scientific and technological divide widens (Tate 2001; Moses and Cobb 2001). Students without access to rigorous science instruction have been and will continue to be left behind. This inequality is salient for students in marginalized communities and schools where stereotypes fuel low expectations for academic achievement and success.

Despite these gaps in science instruction, rigorous science instruction is a topic often discussed by all science educators. We argue for more rigorous and socially just science instruction for all children. Our aim in this article is twofold. First, we offer a framework for teaching science in socially just and rigorous ways: (W)holistic Science Pedagogy (WSP). Second, we provide a lesson example to highlight one way to incorporate the tenets of WSP. This lesson is not intended to be implemented exactly as written; it’s meant to illustrate how to design a justice-oriented science lesson.

The aim of social justice education is to help learners develop “the awareness, knowledge, and processes to examine issues of justice/injustice in their personal lives, communities, institutions, and the broader society while empowering them to connect action to their critical awareness” (Bell 2016, p. 4). WSP is both a teacher- and student-centered instructional approach that encourages a commitment to (a) developing scientific knowledge and (b) doing a critical analysis that moves science away from static facts to a transformative lens necessary to make sense of and make change to the world.

A compelling and current issue today is climate change, so we use it as a context to provide a relevant example. We designed a climate change lesson that aligns with WSP and provided an analysis of how each component aligns with this instructional approach. The lesson addresses Next Generation Science Standard under Earth’s Systems (HS-ESS3-1) and incorporates two of the science and engineering practices: analyzing and interpreting data and constructing explanations. The lesson is rich in content and its focus on social justice. This lesson was designed based on a similar classroom lesson taught by one of the authors and described in another publication (Patterson and Gray 2019). Because this article’s goal is to provide an example of how to teach content while addressing issues of social justice, we explain how each component of the lesson aligns with WSP to show how to design other social justice-oriented science lessons.

### FIGURE 1

**Summary of each WSP commitment.**

<table>
<thead>
<tr>
<th>Commitment</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>An ever-developing commitment to self-awareness</td>
<td>Because our values and ideologies influence instruction, teachers must ever question the foundation of their belief systems. (W)holistic Science teachers interrogate their beliefs and values. Upon finding values that are steeped in oppression or white supremacy, they then do the work of deconstructing these problematic mindsets.</td>
</tr>
<tr>
<td>A commitment to science and its practices</td>
<td>Teachers committed to science and its practices consistently engage students in ways that reflect scientific habits of mind. Such teaching guides students through hands-on, inquiry- and problem-based science experiences that establish multiple points of entry for students using a more expansive array of teaching styles. Instruction is in alignment with contemporary standards and research in science education (e.g., NGSS and its framework).</td>
</tr>
<tr>
<td>A commitment to science as a transformative agent</td>
<td>Science can and should be transformative: Thus, (W)holistic Science teachers engage students in discourse around the historical impact of science in shaping public opinion and ideology on issues of identity, race, class, gender, and other topics.</td>
</tr>
<tr>
<td>A commitment to their students’ social emotional wellness</td>
<td>As classroom and school leaders, (W)holistic Science teachers recognize the necessity of emotionally, socially, and intellectually safe learning spaces for students. In practice, students and teachers are encouraged to envision and imagine ways and practices of learning that are relevant and useful to themselves, the community, and society at large.</td>
</tr>
<tr>
<td>A commitment to restorative practices</td>
<td>This commitment moves beyond restorative practices for disciplinary purposes. But (W)holistic Science teachers acknowledge the trauma that many students experience by virtue of their identity and consider the ways that science is used as a tool to marginalize and maximize opportunities to make amends between marginalized students and the discipline.</td>
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</table>
Holistic Science Pedagogy

As an instructional approach, Holistic Science Pedagogy asks teachers to make five commitments:

- a commitment to an ever-developing self-awareness,
- a commitment to science and its practices,
- a commitment to science as a transformative agent,
- a commitment to their students' social emotional wellness, and
- a commitment to restorative practices.

The result of an interaction between the Holistic science teacher and their students is the creation of a learning space and a set of experiences where students' whole selves and interests are engaged and reflected within classroom science. We briefly outline the commitments in Figure 1. We see this framework as meeting the goals of social justice education within science education. Below, we share a lesson that reflects the five commitments of WSP and aligns with the Next Generation Science Standards (NGSS).

Lesson context

This lesson would typically take place during an Earth science unit exploring the interaction between climate change, natural hazards, and human activity. Prior to the lesson, students would have learned about climate change and should be able to define it and its effects. The activities presented in this lesson give students the opportunity to consider contemporary issues

Selected graphics from the stations activity.

**STATION 1**
Country size reflects its historic CO₂ emissions, 1900-2004

**STATION 2**
Berkeley Earth: January to December 2019

**STATION 3**
Impact of climate change on national economy (1991-2010)

**STATION 4**
21st Century Ecological Sensitivity - Changes in Plant Species
Predicted percentage of ecological landscape being driven toward changes in plant species as a result of projected human-induced climate change by 2100.
related to climate change and its disparate impacts in the United States and globally. Within this lesson, students examine and synthesize information from various sources to create coherent explanations. The objective of the lesson is that students will use evidence to explain the uneven effects of climate change. Our guiding question for the unit is: “In what ways are the patterns and trends associated with climate change impacting diverse communities around the world?”

**Description of the climate change lesson**

The following is a lesson outline for teaching science in socially just and rigorous ways.

**Warm-Up.** To introduce this lesson and activate prior knowledge, the teacher has students answer the following question: “What is climate change? Be sure to include the cause of climate change in your response.” After students write a response, the teacher allows for whole-group discussion. This is not an evaluative task but an activity that allows teachers to check for understanding about baseline knowledge necessary to make sense of information presented throughout the lesson.

**Stations.** Students work in small groups and examine data from various sources. Each data source will be at one of four stations in the form of a graphic representation (see example graphics in Figure 2; all links to graphics are included in Online Connections). At each station, groups answer related questions (see Figure 3). The graphics at each station document the varied consequences of climate change nationally and globally, including economic and environmental outcomes.

**Claim, evidence, reasoning (C-E-R) activity.** After discussing the data collected during the stations activity, students transition to a C-E-R activity that allows them time to synthesize the information gathered. Students are prompted to use three to five pieces of evidence to make a reasoned argument in support of the claim provided (“Climate change has a universal impact on different communities.”) or to use the evidence to make a counterclaim. On the handout provided, students should provide reasoning for how each piece of evidence supports their claim. Figure 4 provides an example of the C-E-R handout.

Once the handout is complete, students return to their groups and share their responses with a goal of noticing what evidence their peers used and resolving any discrepancies. Next, a whole-class discussion would be facilitated to discuss the guiding question and hear students’ claims and evidence.

**Critical reflection.** For the final part of the lesson, students reflect on the following question set individually and then discuss in small groups:

- Given the data presented about climate change,
  - Who was harmed? And, who will be harmed?
  - What was the cause of the harm?
  - Who’s responsible for the harm? How? Why?
  - What ideas do you have about what can be done to repair and/or prevent harm?
  - What might justice look like for those who were harmed?
  - Can there be justice? Why? Why not?

After these conversations, students receive sheets with additional information about climate change and the climate gap (for a list of possible resources see Online Connections).

**Extension activities.** A recommended next step after this lesson is to provide students opportunities to take action and share about the disparate effects of climate change. For this, students form groups and choose one way to disseminate information about the climate gap. Possible presentations could include a video, speech, letter to local organizations and/or government officials, a blog post, op-ed, or an informational handout. These informational resources would include data and graphics that explain the disparate outcomes of climate change and recommendations of ways to reduce the harm to impacted communities.
Alignment with social justice and WSP
The climate change lesson demonstrates key components of (W) holistic Science Pedagogy. This type of social justice approach to science engages students across multiple domains, requiring a variety of skills and strategies. Here we identify WSP commitments best aligned with the lesson. Our aim is threefold: to make explicit the justice-oriented nature of this lesson, to provide teachers opportunities to see where they may already have instructional practices that are just, and to find places where they can provide more justice-oriented teaching.

Warm-Up. The warm-up represents the teacher’s commitment to science and its practices. For this part of the lesson, students draw on their pre-existing knowledge about climate change and its impact. While this is not an experiment, this investigative inquiry demands that students reflect and respond to a query about the nature of climate change and its causes. This activity can surface students’ misconceptions and misunderstandings. This introductory activity mirrors the practices of scientists when conducting investigations, beginning with inquiry and drawing on their base knowledge, while continuously making meaning and sense as they acquire new information.

The warm-up also demonstrates a commitment to the students’ social emotional wellness. Students become knowledge bringers and are asked to share their expertise of science content. Asking students to share what they know can help create an environment where student voice contributes to the learning.

Stations and C-E-R activity. The stations activity reflects the commitment to science and its practices. Much like a community of scientists, students work collaboratively with others as an exercise of collective meaning making. In science, texts include charts, diagrams, graphs, and even pictures. In both the stations and C-E-R activities, students have to closely examine the visual representations of data to make an argument about the patterns and trends associated with climate change and the disparate effects on different communities. Additionally, students look at various pieces of data while engaging in discussion, debate, and eventually drawing their own conclusions. As a part of the C-E-R activity, students created an argument to support their claims and then modified and revised based on new data and information. The process of incorporating new information and findings to enhance understanding of phenomena is at the heart of the practice of scientific inquiry and discovery.

Taken together, both activities reflect the commitment to science as a transformative agent. Students explored climate change as a science-related occurrence that has justice implications. At this point in the lesson, students learn that human-related behavior has led to a crisis that has disparate results.

FIGURE 4

Claim-Evidence-Reasoning handout.

<table>
<thead>
<tr>
<th>PROMPT: You have recently overheard a friend make the following claim: Climate change has a universal impact on different communities.</th>
<th>CLAIM: Do you agree or disagree with your friend? Please write your full claim.</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your response to that claim? Construct an argument that is either in support of or against the claim of your friend. If you disagree with their claim, provide a counter claim and argument. You must use three to five pieces of evidence from the stations activity to support your argument.</td>
<td>EVIDENCE: Identify three to five pieces of information that can be used to support YOUR claim.</td>
</tr>
<tr>
<td>1)</td>
<td>2)</td>
</tr>
<tr>
<td>3)</td>
<td>4)</td>
</tr>
<tr>
<td>5)</td>
<td>REASONING: Why or how does the evidence listed above support your claim?</td>
</tr>
</tbody>
</table>
Critical Reflection. The critical reflection component of the lesson exemplifies the commitments to restorative practices as well as science as a transformative agent. This section asks students to reflect on and discuss some of the critical questions surrounding the climate gap. More specifically, students are put in the position of being problem solvers: working through issues of justice, equity, and fairness, and considering if it is possible to undo harm. Additionally, they consider what role science played in creating this crisis and how science might play a role in the solution.

This point in the lesson provides a forum for students to discuss the societal inequities and injustices, contemplating how the constructs of race and socioeconomic status show up in the crisis, and at which points. Students engage in rigorous discourse around the idea of “repairing harm,” thinking about the individual, community, and greater societal impact. The enduring questions students wrestle with are “What might justice look like for those most vulnerable to climate change?” and “What can be done moving forward to restore the community members and those who created the harm?” These questions require students to develop a restorative impulse within the context of how science can be used to better understand the injustices in the world around them.

Extension Activity. The extension activity captures the commitment to science as a transformative agent. It shows that both the problem of and solution to climate change are tied to science, specifically Earth science. Students were able to build their awareness of how science can make injustice within our world visible. Moreover, students have the opportunity to draw on additional research and their own experience to develop ways to address the climate gap and climate change. This would be a perfect opportunity to incorporate local data and examples of the climate gap. This activity illustrates the importance of science as a tool for transformation and social justice in the lives of everyday people, not just scientists.

Conclusion: Why a social justice approach? Students are whole beings, socialized by way of multiple experiences, interactions, and levels of awareness. As such, educators can no longer rely on socially and culturally irrelevant curriculum if they are to create meaningful, real-world learning. The approach should be holistic, responding to the mental, physical, and emotional needs of the students.

Several research studies have highlighted the experiences and impact of science teachers who have taken on a more social justice and holistic approach to teaching. These science teachers have demonstrated various components in alignment with the five commitments of the WSP. For example, Mr. Carson, an environmental science teacher, centered local environmental problems in his curriculum. Mr. Carson’s students reported feeling more empowered when the instruction took on a more social justice approach (Dimick 2012). Mr. Carson integrated justice and locally relevant content into his lesson. Another example is Mr. Hall, a science teacher in an urban context, paid attention to students’ social, emotional, cognitive, and behavioral state in his class with the aim to build relationships with his students (Milner 2020). According to this science teacher, monitoring and ensuring students’ social emotional well-being showed care for his students, which in turn created opportunities for transformative teaching and learning. Mr. Hall went beyond lesson design but demonstrated his commitment to students’ social and emotional wellbeing through the ways he noticed and addressed his students’ instructional and personal needs.

These teachers demonstrate a commitment to social justice but specifically to their students’ social emotional wellbeing and to science as a transformative agent—two key tenets of WSP. Our aim with (W)holistic Science Pedagogy is to provide a framework that centers teachers on science and scientific thinking as a tool of liberation, healing, and social justice.

ONLINE CONNECTIONS

Graphics for the stations can be found at the following websites:

• https://www.flickr.com/photos/wheatfields/4146943028/
• http://berkeleyearth.org/category/uncategorized/

Additional data for stations:

• https://science.sciencemag.org/content/sci/356/6345/1362/F2.large.jpg
  *width=800andheight=600andcarousel=1

Resources on the climate gap:

• https://www.youtube.com/watch?v=Hx6gJQfGzgo
• http://www.naacp.org/issues/environmental-justice/
• https://www.huffpost.com/entry/the-climate-gap-is-federa_b_209355

REFERENCES


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