Employing Justice-Oriented Curricula and Pedagogy to Support Elementary Teacher Candidates' Future Science Teaching

by Daniel Alston, University of North Carolina at Charlotte; & Lenora Crabtree, University of North Carolina at Charlotte

Abstract

An imperative shift in science education from approaches that emphasize access and identity to those that center justice will require both an inward critical analysis of science as a discipline and outward exploration of the role science might play in creating a more just society. Accordingly, future elementary science teachers need opportunities to consider how science education might be leveraged to create a more just and equitable society. However, many science teacher educators struggle to model justice-oriented pedagogies within discipline-specific instruction; employing justice-oriented approaches is especially challenging in elementary education programs. This manuscript will describe three justice-oriented curricular innovations which supported preservice elementary teachers as they learned to teach science to elementary students. Also described are the rationales for each curricular innovation and the impact of each innovation on student learning. We conclude with a discussion about the strengths and weaknesses of the curricular innovations, their generalizability and the relevance and need for justice-oriented curricular innovations in the current political climate.

Introduction

Advocates for justice-centered science education describe the science classroom as a place in which students and teachers work together to understand and design solutions to societal challenges, many of which are rooted in systemic inequities. (Grapin et al., 2023; Lee et al., 2022). For teachers, shifting toward a justice-centered approach requires both an inward critical analysis of science as a discipline and an outward exploration of the role science might play in creating a more just society (Crabtree & Stephan, 2023; Philip & Azevedo, 2017). Calls for this shift echo those of scholars whose work highlights the importance of justice-oriented frameworks, including culturally relevant pedagogies (CRP) (Ladson-Billings, 1995; 2006), in science education (e.g., Brown et al., 2018; Mensah, 2011; and Morales-Doyle, 2017). Recent research highlights the importance of equipping science teachers to engage in justice-centered teaching and learning not only in dedicated equity courses but at every stage of teacher preparation (Morales-Doyle, 2017; Underwood & Mensah, 2018; Willey & Magee, 2016).

Conceptual Framework: Culturally Relevant Pedagogy

Although CRP is often mistakenly described as a strategy through which educators incorporate facets of a student's home culture to support engagement, Ladson-Billings (2009) conceptualized culturally relevant curriculum and instruction as that which "[prepares students to question] the structural inequality, the racism, and the injustice that exist in society" (p. 140). To further explore this idea, Ladson-Billings (1995) points to the concept of critical consciousness. As described by Freire (1970), critical consciousness involves an awareness of oppressive systems and one's position within those systems that prompts reflective action. Critically conscious teachers reject the banking method, or "education as an act of depositing" (p. 72), and embrace "problem-posing education" (p. 80) in which teachers and students become co-learners (Freire, 1970). Systems of oppression are complex and varied; in addition to race, dimensions including gender, class, and sexual identity play important roles (Collins, 1990).

Future science teachers need opportunities to consider the role of science in perpetuating systemic inequities and how science might be leveraged to create a more just and equitable society (Morales-Doyle, 2017; Sheth, 2019). In a study of pre-service teachers enrolled in CRP-infused science methods courses, participants with heightened critical consciousness were more likely to 1) employ an asset frame when discussing students and 2) recognize the importance of supporting students' socio-political consciousness (Jones & Morgaen, 2022. Approaching science and science education through a critical lens is especially important for those who have experienced marginalization. According to Mensah and Jackson (2018), "due to their educational experiences, both teacher educators and science teacher educators must be open to interrogating and revealing the structural forms of race, racism, and power that manifest through curriculum and pedagogy and cause alienation and exclusion for pre-service teachers of color in their educational history" (p. 31). Additional research is needed to explore how justice-oriented curricula might support teacher candidates from varied backgrounds preparing to teach science to elementary students. To address that need, the authors sought to engage in a study to explore the following research questions:

1) What impact does the inclusion of justice-oriented curricula and teaching practices in an elementary science methods course have on Pre-service elementary teachers' (PSETs) critical consciousness?

2) How do justice-oriented curricular innovations in an elementary science methods course influence PSETs' perceptions of teaching science?

3) How do justice-oriented curricular innovations impact PSETs' sense of belonging in science and education?

This manuscript will describe three justice-oriented curricular innovations employed as a part of this study in an elementary science methods course. Also described are the rationales for each curricular innovation and the impact of each innovation on student learning. We conclude with a discussion about the strengths and weaknesses of the innovations, their generalizability, and the relevance and need for justice-oriented curricular innovations in the current political climate.

Methods

Researchers' Positionality

Both authors of this article attended K12 schools and universities in which science was taught as facts to be memorized and applied by those whose "success" in science courses might lead to professional degrees in medicine or engineering. For both authors, the impetus to support teachers' moves toward justice-centered science education occurred long after completing their undergraduate degrees. The first author identifies as a black, cis-gendered, Christian, gay male. Before becoming a teacher educator, he taught high school Biology in an urban area where much of his teaching focused on rote memorization of facts with very little attention to conceptual understanding or equity-centered teaching. During his doctoral studies, he studied inquiry-based instruction and experienced his first *acknowledged* racial macroaggression. His research revitalized a desire to teach science with the goal of conceptual understanding, while the macroaggression he experienced ignited an interest in equitable science teaching that would fan into flame five years later in his role as a teacher educator. The second author identifies as a white, cis-gender, heterosexual female. The death of a cousin from HIV-AIDS prompted her to explore inequities in funding for science research with the students she taught during her sixteen years as a high school science teacher. Her students' interest in this issue and other justice-oriented questions prompted her to incorporate curricula, including Skloot's (2009) *The Immortal Life of Henrietta Lacks,* into an advanced Biology course. Eventually, a student's advocacy led the second author to join a group of students as a volunteer with an organization serving HIV-positive individuals in their school community (Crabtree & Casto, 2020). In essence, co-learning with students in this setting allowed her to experience a justice-centered science classroom for the first time. A desire to understand these experiences and answer questions prompted by the phenomenon of integrated hallways and segregated classrooms led to a doctoral degree in Urban Education and a new identity as a teacher educator.

Context of Study

The three curricular innovations described in this article emerged from the individual and collective reflections of the authors as they collaborated to redesign their science methods courses to support teacher candidates' sociopolitical consciousness and move toward justice-centered teaching. Foundational education courses in the teacher preparation

program at a large urban research university in the Southeastern United States, at which both authors teach, were recently restructured to reflect the program's commitment to disrupt systemic racism and all forms of social injustice; redesigning methods courses around this priority, however, remains an ongoing task. The specific innovations described below were implemented across multiple semesters and through varied formats (i.e., online and face-to-face classes) in an Elementary Science Methods course taught by the first author.

Participants and Data Collection

Participants for this study were recruited from students enrolled in one section of the undergraduate Elementary Science Methods course. Nineteen students consented to participate in this study. All consenting participants identify as female. Of those participants, nine identify as white, five identify as Black, four identify as Hispanic, and one identifies as Asian. Data sources include student coursework (reflections and discussion posts described in Figure 1) completed in concert with course assignments related to the curricular innovations. In addition, the second author conducted interviews with eight of the consenting participants after the conclusion of the semester-long course. Transcripts of these interviews were also used as data. All participants were given pseudonyms.

Data Analysis

In order to analyze data, the authors used a constant comparative method (Glaser, 1978). We read through the interview transcripts and course artifacts several times to identify common themes. We used open and axial coding to generate codes, collapse codes into categories, and create themes. Throughout this process we performed reliability checks with each other to ensure we were analyzing data similarly as we coded. If there were divergences in our conceptions of codes, we discussed these until we were both seeing data with an agreed-upon lens.

Justice-oriented Curricular Innovations

In this section, we provide a description of each innovation, including the methods through which it was implemented and curricular materials that supported the approach. A brief summary of the three innovations is provided in Figure 1. We attempt to include details in our descriptions of each innovation that might allow teacher educators to implement them in their own settings and encourage others to adapt these approaches to their own unique contexts and needs. While we only include data from an Elementary Science Methods course in this article, the second author has used the first and third innovations with graduate students in a middle and secondary science methods course and found them to be beneficial. Following the description of each innovation, we offer samples of student responses and a brief summary of course artifacts and interview data related to the innovation to illustrate ways these approaches supported our PSETs' moves toward justice-centered science teaching and learning.

Figure 1

Summary of Justice-Oriented Curriculuar Innovations

Curricular Innovation	Summary
#1: Expanded DAST	Students engage in the Draw-A-Scientist activity developed by Chambers (1983). They discuss their drawings in small and whole groups, with facilitation from the professor, to determine what stereotypes their drawings reveal. Following the whole group discussion, the students listen to a read-aloud about Ernest Just, a Black scientist, and use the story to help make sense of why we mostly see white scientists in school textbooks. We also attend to Ernest Just's resistance to the oppressive structures and systems. Following this discussion, students explored the inequitable history of their own university, which also helped students make sense of the limited access people of color and women had to higher education. Students write a reflection about these class experiences, as well as post to a whole-class discussion board.
#2: Heteronormativity Article	Students read an article about the history and evolution of how people in the LGBTQ+ community were understood/categorized and how organizations used this science to oppress people in this community. After reading the article, students write a reflection with prompts that focus on the nature of science and the impact of science on society and vice versa. Students then have a whole-class discussion about the article, facilitated by the course instructor, to highlight aspects of the article that 1) connect to the nature of science, 2) surprise students, and 3) raise questions for students.
#3: Environmental Critical Case Study	Students engage with a case study about the birth of the environmental justice movement, which occurred in Warren County, North Carolina. The case study is presented using six sequential Google Form surveys that expose students to historical occurrences and challenge students to consider the intent and impact of this historical event. Students answer questions as they move through the Google Form surveys. This is accomplished in small groups during class, and after each Google Form Survey, the instructor facilitates whole-group discussion to highlight the oppression and the resistance of populations of color and those that are economically marginalized.

Curricular Innovation #1: Expanded DAST

Curricular innovation #1 engaged students in a modified version of the Draw-A-Scientist (DAST) activity (Chambers, 1983). The original DAST activity involves students drawing a scientist in response to a generalized prompt. In our context, PSETs engaged in the original DAST activity outside of class and then

shared and discussed similarities and differences between their drawings in small groups during a class session. These discussions were designed to elicit student thinking regarding stereotypes that exist around science and scientists. To extend the DAST activity, students engaged with an elementary-level text about biologist Ernest Just called *The Vast Wonder of the World: Biologist Ernest Everett Just* (Mangal, 2018). Just's experiences of racialized discrimination in the early 20th Century prevented him from securing funding for research or employment at institutions with extensive resources; despite those limitations, Just is now recognized as identifying the principles of epigenetics almost a century before other biologists (Byrnes, 2015). While students listened to the book being read aloud, they responded to prompts on a Google Jamboard (e.g., How does Ernest Just's story help us understand the origins of the idea that most scientific discoveries are made by white males?; How does Ernest Just's story help us understand the value of diverse perspectives?) and then participated in a class discussion connecting the DAST activity with Ernest Just's story. Following the class session, students engaged with an online module developed by the first author to learn about the history of exclusion of Black and female students at institutions, including the one they currently attend, and submitted a written reflection on these activities.

Rationale

This innovation was designed to support PSETs understanding of the context in which stereotypes like those elicited through the DAST activity develop. Parsons (2014) challenges science educators and education researchers to avoid presentism and individualism when discussing the marginalized experience. According to Parsons, "Presentism excises the current racial and ethnic arrangements from their historical foundations and dismisses or ignores the uninterrupted continuities from the past to present" (p. 178). Further, presentism keeps us from realizing future possibilities as we attempt to create solutions without knowing how we got to this point (Holland, 1998). Similarly, individualism dissociates an individual's experience from the group-level experience. By ignoring systems-level origins, an individualistic worldview impedes systemic change (Parsons, 2014). If instructors do not facilitate discussions about the historical, systemic underpinnings of contemporary issues, students may walk away from justice-oriented learning experiences with the mindset that inequities are isolated events that exist at a moment in time. Accordingly, Ernest Just's biography and the history of their university reveal the impact of 1) limited access to education for targeted groups, 2) challenges in obtaining research funding and mentorship due to race and/or gender, and 3) failures to listen to and build on the ideas of persons of color.

Student Outcomes:

Course artifacts suggest that grounding a discussion of stereotypes in their historical context supported students' understanding of ways inequitable access to education and resources contributed to false ideas about who can be a scientist. In an online Discussion Forum, one student posted:

My biggest takeaway from this assignment was the book that we read during the class discussion which talked about Ernest Just, a black scientist who studied the cell and made many other advancements in science. The book talked about the challenges he faced as a black man when he had to move across the country to further his education and eventually move to a different continent to study in his field because of the racism he is facing in America. (Beth, DAST Discussion Forum)

As an example of the connections students made between the history of Predominantly White Institutions (PWIs) and the development of those stereotypes, another student stated:

The information [about the history of PWIs] helps us understand why many of my classmates may have drawn white males as their scientists. White males were so often credited for the work that belonged to a woman or person of color. With many white males being unrightfully credited for scientific discoveries, this

conditions us to associate our image of a scientist with a white male. (Carol, Discussion Forum)

Student reflections also revealed emerging understandings of the broad impacts of exclusion: “The information from the follow-up helped to further develop our discussions from Wednesday by demonstrating that Ernest Just’s story was not a single-case incident. Learning about the history of [our university] was new information to me.” (Jasmine, Reflection Assignment)

As they became aware that Ernest Just’s experiences were not isolated but existed for other people of color and women, the modified DAST activity provided opportunities for PSETs to question the structural inequality and racism that may have shaped their own perceptions of who can do science. Opportunities to examine the history of their own university further enabled students to make personal connections to historical, systemic inequities that impact science teaching and learning today.

Curricular Innovation #2: Heteronormativity Article

For the second curricular innovation, students read *Oppression by Scientific Method: The Use of Science to Other Sexual Minorities* (Mohr, 2008). When students were informed of the assignment, the instructor prepared them for the reading by telling them the content of the article might be uncomfortable to read and encouraging them to lean into the discomfort instead of letting it be a barrier. After reading the article, students were asked to engage in an online discussion forum in which prompts (e.g., Pick out two instances of Nature of Science (NOS) and explain how the two you picked represent NOS; What is the article trying to convey about the scientific enterprise?; How did reading this article impact your thoughts about the scientific enterprise?) encouraged them to reflect on the intersections between the content of the article and NOS. Following the reading and discussion post, students engaged in a Gallery Walk and whole class discussion around three questions: 1) What surprised you about the article?; 2) How was the nature of science exhibited in the article?; and 3) What questions do you still have after reading the article?

Rationale:

This curricular innovation was designed with three goals in mind. The first goal was to encourage PSETs to think about and apply the different tenets of the NOS. Science education researchers (e.g., Bell, 2009) emphasize the potential for inquiry activities that position the tenets of NOS within contexts, including historical events, to support students’ understanding of NOS. Secondly, we wanted our students to make connections between the NOS and ways individuals and/or organizations have misused science to oppress groups and individuals, including those who identify as LGBTQ+. Our third goal was to encourage PSETs to think about diversity as more than race and gender. In the last three decades, science education researchers have engaged in more work on race and gender inequities (Mensah, 2018; Morton et al., 2022) and less on inequities that impact sexually minoritized individuals. More recently, science education researchers have started to unpack the latter (e.g., Wright & Delgado, 2023).

Student Outcomes:

Discussion posts and interview data indicate that reading an article about oppression within science supported a deeper and more nuanced understanding of the NOS among this group of PSETs. As one student stated,

We use [science] as a way to make sense of the world, and when something doesn’t make sense in accordance to the rules of life, society, unanswered questions, etc. we look to science to find our answers. But science can be misused when discussing things like human rights and the right to live without fear of violence and hatred. (Lauren, Discussion Forum)

Another student made connections between the themes in the article and the importance of diverse perspectives in science, saying,

It is important to think about scientific topics from a variety of perspectives and to keep an open mind. To me, this is why I believe it is important to have scientists of diverse races, backgrounds, sexual orientations, and identities, in order to provide a variety of perspectives on theories. It is essential to understand that science is constantly changing and is subject to bias. (Carol, Discussion Forum)

During a post-course interview, a student associated a more nuanced understanding of science with her future role in supporting students as critical consumers of knowledge, stating,

It's my responsibility to do my research and it's my responsibility to make sure as a teacher to not just go by what I think I know because I'm…I know it all. I might just know what only a part of it [is] that I kind of just got exposed to. But if I dig deeper and if I make sure that my students also have the opportunity to see the bigger picture, not just a part of it, then I'm doing my job successfully. (Kristy, Post-course Interview)

Engaging in conversations about the NOS in the context of the Mohr (2008) article supported PSETs' awareness that science as a human endeavor can be influenced by and reinforce biases present in society. Kristy's comment that it is important to investigate and, when needed, contest ideas presented as scientific "facts" that may be used to create or reinforce oppression suggests moves toward reflective action, an essential facet of fully realized critical consciousness, as described by Freire (1970).

Curricular Innovation #3: Environmental Critical Case Study

Through the third curricular innovation, a critical instructional case study (Crabtree & Casto, 2020), PSETs explored a historic event scholars refer to as the Birth of the Environmental Justice movement (McGurty, 2000). Questions embedded throughout the case study prompted PSETs to 1) explore primary sources related to the 1982 decision by state officials in North Carolina to place a hazardous waste dump in a racially and economically marginalized rural community; 2) understand ways historically marginalized populations have experienced science as meaningful in their communities, *and* 3) consider ways students might use the knowledge they gain in a science setting to challenge systems of oppression. The six-part case study was employed across two (2) one-hour and fifteen-minute class periods using Google Form surveys as the method of dissemination. Parts 1-3 of the case study follow Kim, a 7th-grade student, as she asks her science teacher and a local librarian to help her understand the potential impacts of a hazardous waste site being constructed in her predominantly African American community. Contemporaneous newsreels, images, and short videos in Parts 4 and 5 provided further opportunities for PSETs to explore this seminal event through the lives of those who experienced it. In Part 6, PSETs were introduced to a new challenge, the question of where to put the toxic coal ash generated by power plants, and encouraged to consider this dilemma through a justice-centered lens. After completing the instructional case study, students were assigned a final course project, which took the form of students working in small groups to create a narrative instructional case study exploring a different environmental justice event or issue.

Rationale:

Initially, the case study employed for this innovation was selected to support PSETs' knowledge of a seminal event that remains "hidden" in the state in which it occurred. Accordingly, we thought it important to provide the PSETs with an opportunity to learn more about their state's history and predicted this connection would support their engagement in the case study (Gruenewald, 2003). In addition, the storyline of the case study highlights student agency and advocacy, an essential aspect of justice-centered teaching (Lee et al., 2022). In the instructional case study, Kim's curiosity and concern for her

family and neighbors prompts her to understand what is happening in her rural community. While Kim is *assisted* by adults, she takes the lead in understanding an impending injustice in the context of science. Finally, while the case study reveals ways marginalized communities have been and continue to be oppressed, it also highlights their resistance, a key facet of sociopolitical consciousness we strive to emphasize throughout our courses.

Student Outcomes:

Post-course interviews suggest that experiencing the case study through the eyes of a young student encouraged PSETs to consider the role teachers might play in supporting students as advocates in their communities. For example, one PSET stated:

This is their home. This is their area, their land, this affects them just as much as it does their parents… and they deserve to have that say of being able to research what's going on to be able to understand what's going on and to be able to know how and where to ask questions. And as teachers, that's our job to teach them how to do that. (Monique, post-course interview)

A second PSET's post-interview comments indicate that engaging in the instructional case study provided the instructor opportunities to model introducing sensitive topics in a justice-centered classroom and allowed PSETs to experience the range of emotions they and young learners may have during conversations about oppression. As one student stated,

So [our professor] did a really good job of just like… kind of explaining and giving us a brief understanding before going into it and letting us know, like, *it's okay to experience discomfort*. …so if I'm introducing a subject that I could sense would be uncomfortable or sensitive for students, giving them that little heads up, that warning, and giving them the space to understand that it's okay to talk about this further. (Jasmine, post-course interview)

Another student's response reveals that engaging in conversations about environmental racism in her methods class helped her make interdisciplinary connections she can explore with students in the future, saying, "We just kind of learned that it's important to talk about these things because they are part of history and they are part of science. So, I think I feel more comfortable now doing things like that" (Lauren, post-course interview).

In summary, our students' responses reflect emerging awareness that while it may be difficult to engage in conversations about racism and other forms of oppression, it is necessary to do so. In addition, the historical context of the case study alerted PSETs to potential interdisciplinary connections, while its protagonist prompted them to see their future students as potential advocates for justice in their communities.

Discussion

The innovations described above evolved as we responded to student engagement, coursework, interview responses, and informal feedback. As we reviewed our data, we noted that while student responses suggest each innovation supported PSETs' critical consciousness as well as a desire to support similar awareness among their future students, essential facets of CRP, the instructional case study was more frequently referenced in post-course interviews as one that supported their emerging identities as justice-centered teachers. A possible explanation for this outcome may be that the instructional case study was the only curricular revision that included an opportunity for students to design lessons similar to what had been modeled for them. Based on this analysis, the first author added an extension assignment to the modified DAST activity. For this assignment, students worked in pairs to research a scientist who identifies or has been identified as being part of a marginalized group (e.g., people of color, women, people who identify as LGBTQ+, people with disabilities) and to research how the scientist was oppressed and how

the scientist resisted oppression. Students were then required to connect the scientist with at least two K-6 science standards and identify a children's book written about the scientist. Students then shared this information through a class Google slide deck and presentation. This revision was implemented in the most recent semester. We are still analyzing its impact, but the results are promising.

A broader analysis of student responses underscores the strengths and weaknesses of the innovations described above. In regards to strengths, two design features of the first and third innovations, the inclusion of historical context and a child's or young adolescent's perspective, appear to have played an important role in meeting our desired learning outcomes. Drawing on interview data, we noted that participants made few connections to the second innovation as one that supported their learning. While the Mohr (2008) article referenced historical systemic oppression, it lacked specific context and an explicit human connection. Therefore, we plan to revise the second innovation by 1) supplementing the Mohr article with resources that highlight inequities in funding for research addressing the cause and treatments for HIV-AIDS, as well as the role ACT-UP played in securing research funding, and 2) incorporate a trade book about Ryan White as an example of a student who encountered school-based discrimination as a result of a medical diagnosis (Moreno & Abbo, 2023; Price, 2015). These revisions are designed to move this innovation beyond supporting students' awareness of inequities to more explicitly understanding ways *science* perpetuated those inequities and equip PSETs with tools to engage in reflective action.

Conclusion

While disparate impacts of global crises underscore the imperative of justice-centered science teaching, ongoing attacks on the rights of teachers and teacher educators to discuss systemic inequities threaten to silence important conversations. These attempts to silence essential classroom conversations highlight the importance of pedagogies that not only promote and sustain non-dominant cultures but also allow students in the mainstream to "develop the kinds of skills that will allow them to critique the very nature of their privilege and advantage" (Ladson Billings, 2014, p. 139). Regardless of their racial or ethnic identity, few of the teacher candidates with whom we work have experienced a justice-centered science classroom and need opportunities to see justice-centered pedagogy modeled and debriefed. Thus, the innovations described above are designed to 1) support PSETs' development of sociopolitical, or critical consciousness in a setting that affirms their unique identities; 2) provide opportunities for PSETs to experience learning in a justice-centered setting; and 3) model ways PSETs might center justice in their own future classrooms.

We offer these curricular innovations not only as opportunities to support PSETs' moves toward justice-centered teaching but also as acts of resistance. We know that conversations will not always go perfectly, and activities may miss the mark. What is important is that we model learning from the imperfections and marks missed, realizing that teaching for liberation is a messy pursuit but one worth doing if we desire to create a more just world. As teacher educators committed to critical praxis, we are grateful to be co-learners with our students on this journey.

References

Bell, R. L. (2009). Teaching the nature of science: Three critical questions. *Best Practices in Science Education, 22*, 1-6.

Brown, B. A., Boda, P., Lemmi, C., & Monroe, X. (2018). Moving culturally relevant pedagogy from theory to practice: Exploring teachers' application of culturally relevant education in science and mathematics. *Urban Education*. https://doi.org/10.1177/0042085918794802

Byrnes, W. M. (2015). The forgotten father of epigenetics. *American Scientist, 103*(2), 106-109. https://doi.org/10.1511/2015.113.106

Chambers, D. W. (1983). Stereotypic images of the scientist: The draw-a-scientist test. *Science Education, 67*(2), 255-265. https://doi.org/10.1002/sce.3730670213
Collins, P. H. (2017). Black feminist thought in the matrix of domination. In C. Lemert (Ed.), *Social theory: The multicultural, global, and classic readings* (pp. 413-421). Westview Press.
Crabtree, L. M., & Casto, A. (2020). Hidden in plain sight: Life lessons taught by gifted Black girls to their white STEM teachers. In N. M. Joseph (Ed.), *Understanding the intersections of race, gender, and gifted education: An anthology by and about gifted Black girls in STEM* (pp. 71-84). Information Age Publishing.
Crabtree, L. M., & Stephan, M. (2023). That exists today: An analysis of emerging critical consciousness in a professional development setting. *Journal of Science Teacher Education, 34*(2), 105-131. https://doi.org/10.1080/1046560X.2022.2031479
Freire, P. (1970). *Pedagogy of the Oppressed*. New York: Seabury Press.
Glaser, B. G. (1978). *Theoretical Sensitivity*. Sociology Press.
Grapin, S. E., Dudek, S., & Lee, O. (2023). Justice-centered STEM education with multilingual learners. *Science Scope, 46*(5). https://doi.org/10.1080/19434901.2023.12290258
Gruenewald, D. A. (2003). The best of both worlds: A critical pedagogy of place. *Educational Researcher, 32*(4), 3-12. https://doi.org/10.3102/0013189X032004003
Holland, D. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.
Jones, B. L., & Donaldson, M. L. (2022). Preservice science teachers' sociopolitical consciousness: Analyzing descriptions of culturally relevant science teaching and students. *Science Education, 106*(1), 3-26. https://doi.org/10.1002/sce.21683
Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal, 32*(3), 465-491. https://doi.org/10.3102/00028312032003465
Ladson-Billings, G. (2011). Yes, but how do we do it? Practicing culturally relevant pedagogy. In J. Landsman & C. Lewis (Eds.), *White Teachers/Diverse Classrooms: Creating Inclusive Schools, Building on Students' Diversity and Providing True Educational Equity* (pp. 33-46). Sterling, VA: Stylus.
Ladson-Billings, G. (2014). Culturally relevant pedagogy 2.0: aka the remix. *Harvard Educational Review, 84*(1), 74-84. https://doi.org/10.17763/haer.84.1.p2rj131485484751
Ladson-Billings, G. (2022). *The dreamkeepers: Successful teachers of African American children*. John Wiley & Sons.
Lee, O., Shelton, T., & Grapin, S. (2022, December 12). Future Approaches in STEM Education. *National Science Teaching Association*. https://www.nsta.org/blog/future-approaches-stem-education
Mangal, M. (2018). *The vast wonder of the world: Biologist Ernest Everett Just*. Millbrook Press.
McGurty, E. (2000). *Transforming Environmentalism: Warren County, PCBs, and the Origins of Environmental Justice*. Rutgers University Press.
Mensah, F. M. (2011). A case for culturally relevant teaching in science education and lessons learned for teacher education. *The Journal of Negro Education, 80*(3), 296-309. *Project MUSE* muse.jhu.edu/article/806906.
Mensah, F. M. (2019). Finding voice and passion: Critical race theory methodology in science teacher education. *American Educational Research Journal, 56*(4), 1412-1456. https://doi.org/10.3102/0002831218818093
Mensah, F. M., & Jackson, I. (2018). Whiteness as property in science teacher education. *Teachers College Record, 120*(1), 1-38.
Mohr, J. M. (2008). Oppression by scientific method: The use of science to "Other" sexual minorities. *Journal of Hate Studies, 7*(1), 21-37.
Morales-Doyle, D. (2017). Justice-centered science pedagogy: A catalyst for academic achievement and social transformation. *Science Education, 101*(6), 1034-1060. https://doi.org/10.1002/sce.21305
Moreno, D., & Abbo, H. (2023). *Hope for Ryan White*. Albert Whitman & Company.

Morton, T. R., Miles, M. L., Roby, R. S., & Ortiz, N. A. (2022). “All we wanna do is be free”: Advocating for Black liberation in and through K-12 science education. *Journal of Science Teacher Education, 33*(2), 131-153. https://doi.org/10.1080/1046560X.2021.2008096

Parsons, E. C. (2014). Unpacking and critically synthesizing the literature on race and ethnicity in science education. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of Research on Science Education, Volume II* (pp. 181-200). Routledge.

Philip, T. M., & Azevedo, F. S. (2017). Everyday science learning and equity: Mapping the contested terrain. *Science Education, 101*(4), 526-532. https://doi.org/10.1002/sce.21286

Price, N. (2015). *The Quiet Hero: A Life of Ryan White*. Indiana Historical Society.

Settlage, J., Southerland, S. A., Smetana, L. K., & Lottero-Perdue, P. S. (2018). *Teaching science to every child: Using culture as a starting point*. Routledge.

Sheth, M. J. (2019). Grappling with racism as foundational practice of science teaching. *Science Education, 103*(1), 37-60. https://doi.org/10.1002/sce.21450

Skloot, R. (2017). *The immortal life of Henrietta Lacks*. Broadway Paperbacks.

Underwood, J. B., & Mensah, F. M. (2018). An investigation of science teacher educators’ perceptions of culturally relevant pedagogy. *Journal of Science Teacher Education, 29*(1), 46-64. https://doi.org/10.1080/1046560X.2017.1423457

Willey, C., & Magee, P. (2016). Clinical experiences and mediational activities in urban teacher preparation: Learning and critical consciousness. *Global Education Review, 3*(4), 1-16.

Wright, G. W., & Delgado, C. (2023). Generating a framework for gender and sexual diversity‐inclusive STEM education. *Science Education*. https://doi.org/10.1002/sce.21786