The Use of Social Justice Socioscientific Issues in Secondary Biology Classes: An Action Research

Stephanie Marilyn Bailey

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THE USE OF SOCIAL JUSTICE SOCIOSCIENTIFIC ISSUES IN SECONDARY BIOLOGY CLASSES: AN ACTION RESEARCH

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For the Degree of Doctor of Philosophy in
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Dedication

This work is dedicated to the thousands of students I have taught and the many more I have yet to meet.
Acknowledgements

Completing a doctoral program is an endeavor that cannot be accomplished without a strong support team, and I have had two. My academic support team has consisted of my committee. I have been lucky enough to work with Drs. Lotter and Carnes who I met many years ago through teacher institutes that forever shifted my teaching practice, my students continue to be impacted by their influence. I also experienced a profound shift in perspective and mission after taking classes with Drs. Boutte and Anders. The classes they taught pushed me to critically consider the world around me, to notice the inequities that exist, and how my students are impacted by this. I continue to strive to serve my students better each day in light of this shift.

My second support team, and by far the most important, is my family. My husband, Chris Bailey, and sons, Walker and Ries, have kept me fed both literally and figuratively. They have kept me motivated and encouraged. They have given me the space to work and the gentle, or not so gentle, reminders to get back to work when I needed them. They have truly been a part of this process since the first day, and I am grateful that they have seen me through this endeavor.
Abstract

The U.S. Education system is founded on a Eurocentric focus of curriculum, and students of color are not achieving as high as white students on the National Assessment for Education Progress in science. This research aims to repay the education debt owed to students of color by decolonizing science curriculum through the implementation of lessons centered around socioscientific issues grounded in social justice. An action research study was implemented in which 9th grade Biology students participated in three instructional units centered on social justice issues. Data was collected through surveys, focus group interviews, student work, and journal reflections from students. After participating in all three units, students were better able to define social justice concerns and identify the role of science in identifying issues of social justice. Students also shifted in their ability to identify issues of equality and the needs of communities based on their studies. Finally, students reported that they were engaged and interested in studying from this perspective. These findings indicate the benefits of instruction from a social justice perspective. This study also shares recommendations for incorporating social justice issues into the socioscientific framework.
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Chapter 1: Introduction

“Far from being neutral, ‘science’ is a socially constructed discipline that is temporarily situated and funded by any who have the resources.”

(Sammel, 2008, p. 853)

Introduction

Eurocentric scientific education presents to students the perspectives, discoveries, and contributions of predominantly White and male scientists (Previs, 2016; Wood et al., 2020). We are all too familiar with British naturalist Charles Darwin (1809-1882), Austrian monk Gregor Mendel (1822 – 1884), American molecular biologist James Watson (born 1928) and his English counterpart Francis Crick (1916 – 2004). What about African American biologist Ernest Just (1883 – 1941), African American medical researcher Charles Drew (1904 – 1950), or African American chemist Marie Maynard Daly (1921 – 2003)? Or, how about Cuban epidemiologist Carlos Juan Finlay (1833 – 1915), Venezuelan American immunologist Baruj Benacerraf (19200 – 2011), or Spanish physicist Luis Walter Alvarez (1911-1988)? Can students who do not see themselves reflected in the content become truly invested in the learning? It is our responsibility to teach all of our students and present as wide a perspective as possible. What would happen if students experienced learning about people who resembled themselves (mirrors) rather than just seeing the contributions of others (windows) (Bishop, 1990)?
Integration of Equity and Relevance in Science

Equity pedagogies (McGee Banks & Banks, 1995) can be effectively merged with science best practices. There is an emphasis within the Next Generation Science Standards and within the K-12 Framework to contextualize science culturally and relevantly (Januszyk et al., 2016; Mensah, 2022). To qualify as a disciplinary core idea within the NGSS ideas must, among other qualifications, “[r]elate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge (NRC, 2012, p. 31). In addition, the Framework acknowledges that:

There is increasing recognition that the diverse customs and orientations that members of different cultural communities bring both to formal and to informal science learning contexts are assets on which to build—both for the benefit of the student and ultimately of science itself. (NRC, 2012, p. 28)

Integration of equity into curriculum is valuable and essential (Ladson-Billings, 2009), but practically, educators need to be reassured that their students will learn the content standards as well. Centering lessons around a sociopolitical issue of local concern frames the content around lived experiences and provides relevance for learning content standards. In reviewing relevant sociocultural literature on science studies, Lyn Carter (2008) recognized the benefits in educators moving beyond mere scientific conceptual knowledge and advocated for student participation in sociocultural and political interests, and thus doing so, moving away from centering Western science and risking the “othering” of diverse students (Carter, 2004).
Engaging students with sociocultural concepts and political interests is not a one-size-fits all formula; several strategies have been incorporated into classrooms with success to meet the needs of the various populations. Reality pedagogy, a development of the works of Chris Emdin (2011) “functions to develop students’ consciousness about the sociopolitical factors that affect their teaching and learning” (p. 286). Two of the components of reality pedagogy were implemented with immigrant Latinx students, cogenerative dialogue and coteaching. Also using reality pedagogy, students experienced opportunities for more involvement during class discussion and experienced support from classmates through use of dialogue (Taher et al., 2017). Students reported being more engaged and motivated in studying the topics when there was a local social justice component (Morales-Doyle, 2018). The use of socio-scientific issues (SSI) such as the pollution from coal power production that often disproportionately affected Latinx and African American neighborhoods in the U.S. were used as a frame of experience in an AP Chemistry course (Morales-Doyle, 2017). This place-based opportunity positioned the students in the role of expert and producer of scientific knowledge which they then presented to a community of parents. These are just a few examples of how social justice can be implemented within a classroom. Julie Brown (2017) conducted a metasynthesis of culturally relevant science studies and cross referenced with instances of applications of nature of science (NOS) practices. Her metasynthesis revealed a lack of inclusion of traditional ecological knowledge and Indigenous views. Notably, she found that of the NOS practices, engaging in argument from evidence was one of the least-frequently used.
Background of the Problem

Educational curriculum has historically been Eurocentrically focused and centered around the contributions from colonizing countries (Swartz, 1992). Tuck and Yang (2012) describe two forms of colonialism: (1) external colonialism (extracting portions of an Indigenous world to build wealth and privilege) and (2) internal colonialism (asserting control over peoples within “domestic” borders). The practice of internal colonialism includes schooling “to ensure the ascendancy of a nation and its white elite” (Tuck & Yang, 2012, p. 5). Leigh Patel (2016) further defines “a key trope of settler colonialism is erasing to replace.” (p. 37):

This erase-to-replace is core to the project of settler colonialism and creates, dysfunctionally, a goal that cannot be achieved. The replacing knowledge can never actually completely fill what was erased. . . Such pedagogy, for populations from nondominant cultures, explicitly seeks to erase existing knowledges and replace them with Eurocentric epistemologies and practices.” (p. 38)

Paulo Freire (2018), in his seminal work, *The Pedagogy of the Oppressed*, describes the role of education from the perspective of humanizing or dehumanizing (oppressing). He describes dehumanizing education “as stimulat[ing] the credulity of students, with the ideological intent (often not perceived by educators) of indoctrinating them to adapt to the world of oppression.” (p. 78). But Freire provides hope as well: “In a humanizing pedagogy the method ceases to be an instrument by which the teachers can manipulate the students because it expresses the consciousness of the students themselves.” (Freire, 2018, p. 69). Tuck and Yang (2012) also provide hope:
We agree that curricula, literature, and pedagogy can be crafted to aid people in learning to see settler colonialism, to articulate critiques of settler epistemology, and set aside settler histories and values in search of ethics that reject domination and exploitation; this is not unimportant work. (p. 19)

Knowing that curriculum within United States schools is historically centered on Eurocentric pedagogies, and knowing that it is possible to structure pedagogies to be liberating and decolonizing (Freire, 2018; Tuck and Yang, 2012), how is science curriculum entwined in colonial pedagogies?

Harding (1994) posed that science educators consider the roots and sources of science and its connections to multicultural foundations that may be neglected. Le and Matias (2019) propose reimagining what science education spaces as educators “need to identify and understand their own whiteness and consider alternative views of science education in the creation of spaces that validate our students of Color” (p. 27). In addition, Battiste (2013a) asserts: “No longer are we able to turn to Eurocentric science and contemporary technologies to rid us of modern society’s mistakes of the past or to clean up our planet for the future of our children.” (p. 167). These arguments are firm in describing a bleak societal future unless we look to other forms of knowing. Aikenhead (1996) recognized the disconnect within the classroom more than ten years earlier, "if the subculture of science is generally at odds with a student's life-world culture, science instruction will tend to disrupt the student's view of the world by trying to replace it or marginalize it ('assimilation')." (p. 5).
The question remains how to avoid presenting a Eurocentric curriculum that typically dominates a science curriculum and in contrast present an equitable curriculum that affirms an ethnically and racially diverse student population to avoid the risk of contributing to marginalization or assimilation? Freire (2018), in the middle of the last century, gave us this answer: “The solution is not to ‘integrate’ [students] into the structure of oppression, but to transform that structure so that they can become ‘beings for themselves’” (p. 74). This liberatory practice is a key component to what Freire (2018) describes as conscientização, or critical consciousness: “the deepening of the attitude of awareness characteristic of all emergence [from oppression]” (p. 109).

Placing students in situations in which they can apply their experiences and knowledge to new settings will work to achieve the goals set forth by John Dewey (1916) and von Glasersfeld (1989). What role can decolonizing science curriculum play in transforming the education structures to support our diverse students to become “beings for themselves”?

**Statement of the Problem**

In 2013 the Next Generation Science Standards (NGSS) were released to “improve science education through three-dimensional learning” and are a blend of disciplinary core ideas, science and engineering practices, and crosscutting concepts (NGSS, 2013). Hoeg and Bencze (2017) analyzed the language of the NGSS to determine the prioritized values of this new set of standards. In the language of the standards (K – 12) they found that only “forty percent of performance expectations contain either participatory knowledge or practices and therefore, allow some variation
and flexibility in the expected performance.” (p. 290). This language of participatory knowledge or practices is how Hoeg and Bencze (2017) interpreted where there were opportunities to incorporate cultural relevance: less than half of the standards did so, even though the authors state that the NGSS was developed with socially just claims. However, Hoeg and Bencze did recognize that the way the standards were written allowed for school districts to be “more critically aware of the need for liberal and alternate interpretations of the knowledge and practices outlined in the NGSS.” (p. 296), thus providing some flexibility in local entities deciding how to incorporate culturally relevant and critically conscious components. While the language of the content standards within the NGSS is lacking in cultural relevance, the Appendix D documentation provides opportunities and explanations to address cultural consciousness through a focus on the nature of science and those who do science (Januszyk et al., 2016).

Given the Eurocentric domination of science instruction, I will address the gap through the use of social justice topics within socioscientific issue methodology (Presley et al., 2013; Sadler et al., 2016b). A decolonizing science curriculum is defined for this study as one that (1) highlights the contributions of Black, Latinx, Indigenous, and other underrepresented peoples to science, (2) acknowledges and addresses issues of historical injustices within science, (3) acknowledges and recognizes issues of sociopolitical context, and (4) does not shy away from challenging discussions and topics (Gorski, 2008).

Decolonizing practices have been implemented in a more concerted effort in schools that serve student populations with specific diversity. In countries like New
Zealand and Canada, that have strong Māori and First Nations connections, decolonizing efforts have been more purposeful at not only the subject level but also within the school and curriculum design as a whole (Aikenhead & Elliott, 2010; Belczewski, 2009; Martin et al., 2020; Robertson, 2003). For example, in Saskatchewan, the textbook authors consulted with the elders of several First Nations to collaborate on the content of text (Castagno & Brayboy, 2008). Textbooks often become de facto curriculum in science classrooms (Summers et al., 2019); therefore this consultation will allow for Indigenous knowledge to be more readily incorporated into the content. Within the United States, decolonizing strategies have been more prevalent in specific geographical regions. Cervantes-Soon and Carillo (2016) focused on studying schools in the Southwestern United States, where schools serve larger populations of Latinx students. Here they explored border pedagogies that decolonize through valuing students’ home languages and cultural experiences rather than viewing them as a cultural deficit. In the Western US, where Native American students attend school, there are efforts in place to redefine what success means in terms of the Native communities within STEM studies; success in terms of the community and across generations rather than solely at the individual level (Howard & Kern, 2019). In urbanized areas with larger populations of students of color decolonizing practices are found as well that explore environmental impact of their areas, strategies to honor cultures, and focused efforts to raise involvement and achievement of students of color (Chatmon & Watson, 2018; Gonzales & Shields, 2015; Sintos Coloma, 2020; Zocher & Hougham, 2020).
Significance of the Study

Gloria Ladson-Billings (2013) argued that rather than an achievement gap there exists an educational debt encompassing historical, economic, socio-political, and moral aspects to determining curriculum, instructional delivery, and texts. This debt is evident in science achievement (Figure 1.1) between White 8th grade students and Black and Brown 8th grade students (African American, Latinx, and Native American) as measured by the National Assessment for Educational Progress (NAEP) (NCES, 2015). Ladson-Billings acknowledged the role of culture in teaching and learning and theorized culturally relevant pedagogy which is founded on three principles: Developing students’ (a) academic achievement; (b) socio-political consciousness; and (c) cultural competence (1995a and 1995b). Since its inception, other scholars (Paris, 2012; Paris & Alim, 2014) have enhanced the theory to focus on the importance of sustaining cultural relevance in the lives of students and the institutions of schooling described as culturally sustaining pedagogy: an approach to teaching and educational policy in which not only are students’ cultures made relevant in classrooms but are sustained as part of the curriculum, the lives of the students, and the structures of schooling (Paris, 2012).
Figure 1.1.
*Average score for 8th grade students on science NAEP test by racial group for three testing years. *Indigenous represents American Indian/Alaska Natives.*

The educational debt reaches as far back as “the color line” that W.E.B. DuBois described in 1903 and was reiterated by Carter G. Woodson 30 years later: “to handicap a student by teaching him that his black face is a curse and that his struggle to change his condition is hopeless is the worst sort of lynching.” (loc 166). We again hear this same sentiment from Linda Darling-Hammond (2005):

Despite the rhetoric of American equality and the effects of school desegregation and finance reform, the school experiences of African American and other “minority” students in the United States continue to be substantially separate and unequal. (p. 202)

In fact, in writing about Afrocentric curriculum, Molefi Kete Asante has found that “children who are centered in their own cultural information are better students, more disciplined, and have greater motivation for schoolwork” (1991/1992, p. 30).
this established knowledge and research, culturally relevant and culturally sustaining pedagogies have been challenging to include in classrooms (Samuels, 2018).

Given this education debt owed to so many students of Color, this study’s significance seems clear: (a) if we do not see students of Color investing, engaging, and achieving at the same level as their White peers (NCES, 2015); (b) if pedagogy has not changed substantially since colonizers first instituted Eurocractic curricula hundreds of years ago (Darling-Hammond, 2005); and (c) if we know that students’ investment, engagement, and achievement is largely tied to their opportunities to not only see themselves in the history of contributors to the world’s knowledge but to know that they are believed in by teachers as already knowledgeable and capable of further learning (Ladson-Billings, 1995b; Dunac & Demir, 2007), then we have a responsibility as educators to overturn a status quo that continues to keep these students from experiencing success.

**Theoretical Frame**

As a trained marine science researcher and secondary science educator I felt it was my duty to help students discover what I thought was the truth of science. Previously, I had a positivistic view of the world: there was one truth, and it was just a matter of discovering what that truth was. Over time, my positivistic views of the world began shifting towards a more interpretive (Prasad, 2018) and more critical perspective (Anderson, 2014; Freire, 2018); I will discuss viewpoints later. With this background in mind, my theoretical framework now encompasses four bodies of thought: social constructivism (Hodson, 1998; K. C. Powell & Kalina, 2009; Vygotsky, 1978), critical
theory (Anderson, 2014; Prasad, 2018), decolonizing pedagogies (Battiste, 2013; Freire, 2018; Tuck & Yang, 2012), and culturally relevant teaching (Ladson-Billings, 1995a, 1995b, 2014a) (Figure 1.2). As I approach this work with an onto-epistemological view that stems from an interpretivism paradigm and a more critical/social constructivist epistemology, a combination often identified as a postcritical orientation to research (Noblit et al., 2004), I am led to ask questions about understanding how students are affected, respond to, and interpret their learning (Glesne, 2016).

Social constructivism is a theory of learning developed by Lev Vygotsky (1978) in which he describes how students learn through social interactions, cooperation among peers, and with scaffolded support from the teacher. Using social constructivism, teachers place students in collaborative groups and foster situations in which they create their own learning and understanding from the experiences curated by the teacher. For a social constructivist, the goal is to place students within the zone of proximal development: “the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers” (Vygotsky, 1978/1930, p.79).

Critical theory is centered on understanding sociocultural structures and working toward liberation and self-awareness (Prasad, 2018). Culturally relevant teaching is founded on the three tenets of (1) academic achievement expectations for all, (2) an appreciation for cultural competence, and (3) a focus on sociopolitical consciousness (Ladson-Billings, 1995b). Finally, decolonization, as I have defined it, is centered
around the works of Paolo Freire (2018) in which the cooperation and purposeful organization of like-minded individuals work toward conscientious liberation.

Figure 1.2.
*Theoretical framework: intersection of culturally relevant, social constructivist, critical theory, and decolonizing pedagogies.*

**From Social Constructivist to Critical Theories**

I am passionate about engaging students with discovery, application, and growth in scientific understanding. I have come to realize that I approach instruction from a social constructivist (K. C. Powell & Kalina, 2009; Vygotskiĭ & Kozulin, 1986; Vygotsky, 1978) and a growing critical perspective; students who have the opportunity to interact with each other and explore their relevant world seem more interested and engaged in their learning. In addition to the social constructivist, I find myself shifting
towards a critical perspective as well, one in which race is centered, ideologies are challenged, and social justice is forefront. I have taken up the challenge given by Solórzano, “to create, recreate, and recover knowledge and art in Communities of Color.” (1997, p. 15). However, in order to produce an accepting atmosphere for students who belong to diverse cultural groups, instruction should come from a decolonizing perspective (Freire, 2018).

**Instructional Frames**

*Socio-Scientific Issues (SSI)*

I propose pursuing decolonizing science curriculum starting from the foundation of instruction centered on socio-scientific issues. Socio-scientific issues (SSI) are defined as: “social dilemmas with conceptual ties to science” (Sadler, 2004b, p. 387). These issues, being defined as dilemmas, typically entail a component of controversy for which there is not a simple answer. Typical topics may include choosing whether to vaccinate, the production of genetically modified crops, or the use of hydraulic fracturing, or fracking, in the extraction of oil. Teaching through the framework of SSI involves three phases: (1) encountering the focal issue, (2) three-dimensional science learning, and (3) synthesis of key ideas and practices (Sadler et al., 2016a). In this process the focal issue, or controversial topic, is presented at the outset to engage students and provide a purpose for their study and to ascertain their initial perspectives of the focal issue. The second phase, three-dimensional science learning is the implementation of best practices of investigative, inquiry-based science that will provide the students with content knowledge to help them assess the focal issue. Finally, the third phase, provides an
opportunity for students to put together what they have learned in the context of the issue and come to an opinion, decision, or recommendation (Presley et al., 2013). The resulting discourse, use of argumentation, and presentation of multiple views has shown an awareness to differing views, increased consideration for others, and an increase in moral sensitivity (Chowdhury et al., 2020a; Sadler, 2004a; Zeidler & Nichols, 2009). These qualities support a culturally relevant classroom in which cultural competence is appreciated and sociopolitical context is central.

**Social Justice in Curriculum**

Incorporating social justice into the classroom setting can be challenging. Often in education, the phrase social justice is used interchangeably with controversial topics. For this study, social justice is defined as justice that serves to dismantle the institutionalized root causes of problems that influence social, political, and economic structures that prevent some people from participating as full partners in social interaction (Fraser, 2007; Westheimer & Kahne, 2004). A school that incorporates social justice into its curriculum is committed to teach “an understanding of the nature and manifestations of all forms of social oppression; provides strategies for intervening in oppressive situations; and seeks to facilitate a living and learning environment for the development of liberatory thinking and action” (Carlisle et al., 2006, p. 61). These schools incorporate five common components within their curriculum: (1) content mastery; (2) tools for critical analysis; (3) tools for social change; (4) tools for personal reflection; and (5) an awareness of multicultural group dynamics (Gewirtz, 2006; Hackman, 2005). Using social justice as a focus for instruction can develop students’ skills in critical thinking,
reasoned judgement, and respect for others’ opinions (Al Badri, 2016; Bull, 2009). The components of social justice education also support the qualities of culturally relevant pedagogy, decolonizing strategies, and critical theory.

**Purpose of the Study**

The purpose of this study is to decolonize science instruction through the incorporation of social justice socio-scientific issues into instruction. This study will focus on three research questions:

**Research Questions:**

1. How do students characterize the connection of science to social justice issues?
2. How do students perceive their experience of learning social justice socio-scientific issues?
3. How do students describe the applicability of social justice socio-scientific issues to real-world contexts?

**Definition of Terms**

*Environmental racism* – The disparate impact of environmental pollution on minority communities. (Covert & Konczal, 2016)

*Nature of Science (NOS)* – A perspective on how science is conducted based on seven components: (1) tentativeness of scientific knowledge; (2) observations and inferences; (3) subjectivity and objectivity in science; (4) creativity and rationality; (5) social and cultural embeddedness in science; (6) scientific theories and laws; (7) scientific methods (Dagher & Erduran, 2016)
Racial essentialism – “[B]elief that races are natural “biological” kinds that differ in humanly important ways because each race possesses a different genetic or biological essence” (Donovan, 2015, p. 1096)

Scientific racism – Use of scientific principles to attempt to establish hierarchy of races places Blacks as inferior. (Taylor, 1981)

Social Justice - Justice that serves to dismantle the institutionalized root causes of problems that influence social, political, and economic structures that prevent some people from participating as full partners in social interaction. (Fraser, 2007; Westheimer & Kahne, 2004)

Socio-scientific issues (SSI) – Topics for learning based on societal issues with an association to science. (Sadler, 2004b)

Whiteness – The racial identity of white persons in the United States that results in public and private societal benefits and racialized privilege. (Harris, 1993)

Characterized by (1) unwilling to identify racism, (2) avoid identifying with a racial group, and (3) negate the legacy of racism. (Gillborn, 2005)
Chapter 2: Literature Review

Introduction

In this chapter, it is necessary to situate this study in the context of the existing research of socio-scientific issues and social justice. I will first present an overview of decolonization in the context of science education curriculum. I will then focus the review on decolonizing strategies that are specific to science instruction, particularly culturally relevant pedagogy, socio-scientific issues, and the incorporation of social justice. And, finally, I will review literature that describes instructional approaches that demonstrate success with marginalized students.

Decolonizing Education

This research is focused on a theoretical frame in which race is centered, ideologies are challenged, and social justice is forefronted. I have taken up the challenge given by Solórzano to “challenge race, racism, and racial stereotypes” in my classroom (1997, p.14). Ladson-Billings and Tate (1995) put forth the charge to apply the foundations of critical race theory to the field of education, pointing out the centrality of race in perpetuating inequities in education and the intersection of race and property in the development of curriculum.
Decolonization.

As I became cognizant of my shift toward critical theory, I gradually became aware of the colonization of pedagogy, practice, and policy. I began to notice how “controlled distance with students, neutrality of subject matter, and silence of the lives of students hide Eurocentric domination.”; these words, part of a lecture given by Marie Battiste (2013b), professor of educational foundations at the University of Saskatchewan, illustrate how easily Eurocentric hegemony and White Supremacy infiltrate and are foundational to the curriculum. Presenting curriculum as culturally neutral fosters the manipulation and cultural invasion that further promotes colonial perspectives (Freire, 2018). Freire (2018) described manipulation as “attempts to anesthetize the people so they will not think.” (p. 149) and cultural invasion as actions of colonizers that “impose their own view of the world upon those they invade and inhibit the creativity of the invaded by curbing their expression.” (p. 152). Curriculum that denies students the opportunity to see contributions of scientists who represent their culture perpetuates the myth that science is neutral.

Students are often focused on the objectivity and empirical nature of science; that it is a collection of facts not influenced by bias, culture, or any other perspective (Cofré et al., 2019). However, science has been riddled with and complicit in perpetuating racist views, known as scientific racism (Menand, 2001). Carl Linnaeus, credited with developing the biological system of classification, in 1735 ordered humans into four distinct groups (species) based on skin color: Europaeus albes[ens] (white), Americanus rubesc[ens] (red), Asiaticus fuscus (tawny), and Africanus nigriculus (black) (Müller-
Wille, 2014). Armed with prejudice against all people who were not White, scientific racism was bolstered by Samuel Morton and his erroneous cranial measurements which he used to hierarchically order the races based on intelligence (which he equated to cranial size) (Gould, 1991; Menand, 2001). These measurements (and others similar) were used to support claims that human races were either descended from or belonged to different species (Gould, 1991; Moore & Chung, 2005). His methods of measurements, manipulation of data, and errors in statistical analyses were later discovered, but the damage was done, perceptions were already forged. Such erroneous claims and conceptions of abilities and intelligence of various racial groups have persisted throughout the educational system, even perpetuating Social Darwinism which is a belief that those who cannot keep up with the dominant White society should be left to perish (Jeynes, 2011). In the 21st century, the assumption of race as a genetic or biological component has led to the misdiagnosis of ailments that are thought of as belonging to one race or another (Goodman, 2000). Yudell and colleagues (2016) posited: “the use of biological concepts of race in human genetic research—so disputed and so mired in confusion—is problematic at best and harmful at worst” (p. 564).

This information became part of the hidden curriculum: the underlying content that pervades subliminally throughout curriculum design, instruction, and textbook content (Donovan, 2014; Ladson-Billings, 2018). And, as argued by Ladson-Billings and Tate (1995), curriculum is a form of property, one that favors White, Eurocentric values. It is inconsequential whether the educational system’s perpetuation of White supremacy and institutional racism is accidental or deliberate, because, in either case, the
eradication of White supremacist views has not been prioritized (Gillborn, 2005). Knowing this, it is essential to examine our curriculum and shift to a focus of decolonization.

A recognition of “the contradictory nature of education, wherein schools most often oppress and marginalize while they maintain the potential to emancipate and empower” (Yosso, 2005, p. 74) has motivated me to seek to provide a counternarrative. To achieve this, I situate myself at the intersection of culturally-relevant pedagogy, decolonizing theory, and critical theory in which cultural competence and a critical consciousness on the part of students and teachers are essential. Milner notes: “Teachers can play a critical role in how students engage, conduct themselves, learn, and achieve in urban classrooms.” (2011, p. 88). I believe this is true in any classroom.

**Decolonizing Education**

Tuck and Yang (2012) identified schooling as a component of internal colonialism in which “getting communities, youth, children, and families caught up with white and middle-class people” (p. 5) is still the goal. The authors identified the practices of schools that erase the contributions, experiences, and lived histories of cultures other than European. Marie Battiste (2013a) shared a glimpse of the effects of *erase to replace*:

Aboriginal peoples in Canada and Indigenous peoples throughout the world are feeling the tensions created by a Eurocentric education system that has taught them to distrust their Indigenous knowledge systems, their elders’ wisdom, and their own inner learning spirit. (p. 24)
With distrust in their own systems of knowledge and Eurocentric education leads to a loss of knowledge and a loss of experiences, tangibly seen through the mere loss of languages of Indigenous peoples across North America. Freire (2018) summarizes and provides a directive for education that will remedy *erase to replace* practices: “Knowledge emerges only through invention and re-invention, through the restless, impatient, continuing, hopeful inquiry human beings pursue in the world, with the world, and with each other.” (p. 72). As science teachers, we can support students in their pursuit of inquiry within the world and guide them to critically analyze the world around them. Pursuing this hopeful inquiry within the classroom will connect students to their world and with each other, undoing the previous erasure.

Authors such as Paul Gorski and Binaya Subedi advocate for strategies to decolonize curricula. Gorski (2008) prescribes seven shifts for teachers to undertake in decolonizing their classroom and curriculum. The first shift, **cultural awareness is not enough**, exposes “hegemonic meaning-making regarding difference” (p. 522) in which being aware of dominant cultural norms that foster White dominance and oppression of the minority is made known. The second shift, **justice first, then conflict resolution**, brings awareness to avoid reifying the existing social order and leaving injustices unresolved. The third shift, **rejecting deficit theory**, recognizes that deficit theory is “a diversion from the goal of dismantling oppression” (p. 522). This shift also recognizes that often students from non-Eurocratic cultures are viewed as culturally deficient, instead of valued and honored for the cultures they bring. Gorski’s fourth shift, **transcending the dialogic surface**, acknowledges power imbalances and recognizes the
oft-placed burden of expecting “least powerful participants to teach their privileged counterparts about oppression” (p. 523). Too often, minoritized people are relied upon to explain oppression and to teach their privileged peers how to not oppress. Shift five echoes the works of Gloria Ladson-Billings: **acknowledging sociopolitical context.** This shift calls for recognizing, analyzing, and critiquing the place curriculum holds in greater society and its role in maintaining status quo. Shift six, ‘**neutrality** = status quo,’ asserts that the mere claim of neutrality is assent to the current status; therefore, Gorski argues “intercultural work must be explicitly political, against domination and for liberation; against hegemony and for critical consciousness; against marginalization and for justice” (p. 523). Finally, Gorski asserts in his recommended seventh shift that there is a strong **likelihood of losing likeability:** “Practicing decolonizing intercultural education requires that I speak truth to power, challenging hegemony and hierarchy. I cannot undertake these challenges authentically without being disliked by many individuals and most institutions.” (p. 523).

Subedi (2013) frames the methods for decolonizing into three approaches: (1) **antiessentialism,** (2) **contrapuntal readings,** and (3) **ethical solidarity.** These approaches overlap and blend well with the “shifts” Gorski (2008) prescribes. Antiessentialism involves critically investigating the cultural practices that have set up sharp distinctions between Eurocratic and non-Eurocratic cultures. Three of Gorski’s (2008) shifts – 1, 3, and 5 - fit within the antiessentialism approach by mandating a situation in which Eurocentric views are decentered and require that educators and students position themselves as critical consumers and purveyors of education. In
essence, an antiessentialism approach is a methodology that sustains the culture of the students and dismantles a dominant, White narrative (Paris, 2012; Paris & Alim, 2014).

The second approach presented by Subedi (2013) references the use of contrapuntal readings, which are curricula and readings that explicitly question colonization and imperialism. It also encourages the use of critical analysis to reflect or acknowledge the perspectives and voices of the marginalized when traditional texts are used. Lessons and readings can, and should be, used to facilitate the transcendence and inclusion of individual stories and experiences of students. When inclusion is attained teachers can center students as experts (Gorski’s shift 1), transcend the dialogic surface (Shift 4), and reject deficit theory (Shift 3). Incorporating readings that represent views contrary to the mainstream, Eurocratic norm centers sociopolitical context (Shift 5) within curricula and avoids “doing the bidding of the powerful in the name of intercultural education.” (Gorski, 2008, p. 523).

Subedi’s final approach is described as ethical solidarity in which an emphasis is placed on seeking “possibilities to develop consciousness that is emancipatory” (p. 635). These approaches harken to Ladson-Billings’ (1995b) call to sociopolitical consciousness and the charge to tackle those aspects of social justice.

Culturally Relevant Pedagogy

Ladson-Billings (1995a, 1995a, 2016) developed and clarified a theory of culturally relevant pedagogy after studying teachers who were successful in educating African American students and attributed the successes to three common elements: academic achievement, cultural competence, and sociopolitical context. In classrooms where
these elements prevailed, the teachers manifested certain common characteristics. Successful teachers demonstrated a belief that all students were academically capable, that pedagogy is an artform, and that teaching is a community endeavor. Successful teachers also centered and maintained relationships and connectedness with their students and encouraged collaborative learning within their classrooms. Successful teachers viewed knowledge critically, facilitated learning, and assessed using multifaceted approaches. However, Ladson-Billings (Ladson-Billings, 2014b) has acknowledged that as with any good pedagogy, culturally relevant pedagogy has to evolve. Django Paris (2012) has contended that rather than simply ensuring pedagogy is relevant, or even responsive, pedagogy should be sustaining: “to perpetuate and foster—to sustain—linguistic, literate, and cultural pluralism as part of the democratic project of schooling” (p. 95).

Culturally relevant/sustaining pedagogies in schools depend on the appropriate preparation of teachers; unfortunately within teacher preparation, inequities abound (Ladson-Billings, 2018). Teacher education programs have consisted of predominantly White instructors and White preservice teachers: 5.5% of all full-time faculty in degree-granting postsecondary institutions are Black, while 10% are Latinx (de Brey et al., 2019) and 6% of preservice teachers are Black while 8% are Latinx (edTPA, 2018). Some institutions have opportunities for preservice teachers to focus preparation to teach students of color: University of South Carolina, Teachers College at Columbia University, and Temple University (among others). However, in a holistic review of programs in which preservice teachers are being prepared to serve diverse student
populations, Whiteness was central within education programs often only offering “add-on” cultural or diversity courses, which were found to be lacking and overly concerned with the comfort level of White preservice teachers based on a survey of universities and teachers in two large urban school districts (Sleeter, 2017).

Teacher certification practices also perpetuated Whiteness when they avoided addressing, or considering race, and when they maintained colorblind perspectives of teaching practices and teacher assessments, reinforcing Eurocentric curriculum. This colorblind ideation was maintained when preservice teachers were placed in schools for their internship experiences that did not provide opportunities to put into practice the culturally relevant pedagogies they had learned (Mensah, 2019; Sleeter, 2017). While preservice teachers had been prepared with culturally relevant pedagogies, their cooperating/supervising classroom teachers had not been prepared, and instead touted colorblind practices.

Curriculum and standards have been influenced by Whiteness in that they (1) neglect to address racism – instead blaming achievement differences on circumstances such as meritocracy, poverty, or cultural deficit, (2) avoid acknowledging the experiences and contributions of minoritized groups, and (3) minimize racist legacies (Gillborn, 2005). A review of Nature of Science (NOS) research revealed that colorblind ideologies existed: no account for race or diversity was recognized among teachers or students (Walls, 2016). In order to produce an accepting atmosphere for students who belong to diverse cultural groups, instruction should come from a decolonizing perspective (Freire, 1968/2018).
Social Justice

Paulo Freire (2018) describes conscientização, or critical consciousness, as “the deepening of the attitude of awareness characteristic of all emergence [from oppression]” (p. 109). This conscientização, or critical consciousness, is the foundation of social justice. The first use of the term social justice has been credited to the Sicilian priest, Luigi Taparelli d’Azeglio in 1840 in which he describes social justice as leveling all persons in regard to their rights of humanity (Burke, 2010). This leveling reiterates the views of John Stuart Mill (Mill, 1910) who said “… we should treat all equally well … who have deserved equally well of us” (p. 57). However, Gerwitz (2006) argues that social justice is relevant and changing depending upon the contextual example, making it a challenging concept to definitively define. For this study, the context of application for social justice lies within classrooms. The working definition of social justice for this study is: justice that serves to dismantle the institutionalized root causes of problems that influence social, political, and economic structures that prevent some people from participating as full partners in social interaction. (Fraser, 2007; Westheimer & Kahne, 2004). Therefore, the issues around which instruction will be framed will be narrowed to issues in which some members of society are prevented from participating as full partners in social interaction.

Decolonizing Science

In my statement of the problem, I identified four areas which described a decolonized classroom as one that: (1) highlights the contributions of Black, Latinx, Indigenous, and other underrepresented peoples to science, (2) acknowledges and
addresses issues of historical injustices within science, (3) acknowledges and recognizes issues of sociopolitical context, and (4) does not shy away from challenging discussions and topics (Gorski, 2008). These approaches align with Gloria Ladson-Billings’ (Ladson-Billings, 1995a, 1995b) theory of culturally relevant pedagogy and the culturally sustaining pedagogy proposed by Django Paris and Samy Alim (Paris, 2012; Paris & Alim, 2014) in that a decolonized classroom provides for cultural competence, sociopolitical context, and a challenge to social justice.

(1) Highlighting contributions.

Decolonized classrooms work to dismantle the focus on Eurocentric contributions and highlight contributions of traditionally marginalized groups while being careful to avoid tokenizing, slipping into the trope of a cultural fair, or focusing on these contributions for only one month. The incorporation of Black Cultural Ethos (BCE) – aspects of spirituality, affect, harmony, orality, social perspective of time, expressive individualism, verve, communalism, and rhythmic-movement expressiveness—demonstrated an improvement in science achievement as measured on a post-test in three middle school science classrooms, whereas in classrooms that did not use BCE, two middle school science classrooms at the same school, a negative change on the same assessment was observed (Parsons, 2008). Incorporating culturally-relevant examples of scientists such as Ernest Just (made discoveries of cell membranes) and Charles Drew (devised methods for blood banking) have demonstrated positive results in engagement and achievement of students in science courses (Boutte, Kelly-Jackson, & Johnson, 2010; Boutte, 2016). When African American students were given opportunities to
contextualize their learning in reference to historical contributions of African American scientists, like Madame C.J. Walker (developed cosmetics for Black women in early 1900s), students experienced greater achievement than without the connection (Boutte et al., 2010). In another study, Indigenous students who were partnered with a tribal mentor who participated in school day activities and field trips had increased attendance rates and improved passing of science and mathematics courses, including a desire to continue with STEM studies (Stevens, Andrade & Page, 2016).

(2) **Acknowledging historical injustices.**

“Science provided the legitimatization for racial inequalities to take root. I wonder in what ways are we promoting or maintaining these and countless other legitimizations by the reluctance of those involved with the teaching and learning of science to name this agenda?” (Sammel, p. 853)

Boutte *et. al.* (2016) provided suggestions for critically analyzing historical injustices in science. This act of analysis elevates the study from simply highlighting contributions to placing them in a historical context that was fraught with injustice. The authors suggested investigating the racist comments of Nobel Laureate James Watson (credited with discovering the structure of DNA), or the injustice experienced by Charles Drew who developed the technology for blood banks but was (according to some sources) denied access to a needed blood transfusion after a car accident. Investigating incidences such as the Tuskegee experiments, Holmesburg prison experiments, the atrocities of J. Marion Sims, and the theft of the cells of Henrietta Lacks would place into context the
hesitation many people of color have in trusting in the newly-developed COVID-19 vaccines or other scientific advances (Norris, 2020)

**Racial Essentialism.** Racial essentialism is defined as a belief that the outward phenotypic appearance of a person correlates to the abilities and skills of the person and that the racial signifier is constant (No et al., 2008). Modern biology textbooks seem to avoid addressing race head-on; rather than present a discussion describing that there is no biological link to race (Pigliucci & Kaplan, 2003), the focus is limited only to inheritance of traits such as skin and eye color or frequency of genetic disorders. When textbooks ignore race, they neglect to recognize the nuance and discrimination that exists within scientific study that has occurred at the hands of scientists (Donovan, 2015). Connecting race to the prevalence of genetic disorders (such as sickle cell or Tay-Sachs) can lead to racial essentialism and an extrapolated view that not only diseases but behaviors and intelligence are inherent within specific racial groups (Donovan, 2016). The connection between racism and anti-evolutionary thought is exemplified in the case of *Epperson v Arkansas*. The case brought to light the fear possessed by White supremacists of Arkansas that, should evolutionary ideas be taught, students would be presented with evidence that Whites and Blacks shared a common ancestor and were therefore not biologically different. (Moore, 2001; Moore & Chung, 2005)

**Environmental Racism.** Environmental racism is the term given to describe the disproportionate occurrence of environmentally hazardous materials near communities of color (Covert & Konczal, 2016; Evans & Kantrowitz, 2002; Mohai & Bunyan, 1992). Race is the most significant predictor of a person living near contaminated air, water, or
soil (Covert & Konczal, 2016). Recently, two such communities that have experienced environmental racism are Mossville, Louisiana and Flint, Michigan (Covert & Konczal, 2016; Hines, 2015). Mossville is a town whose residents are predominantly African American, that is surrounded by 14 industrial plants that have been releasing toxins into the air, water, and soil. The townspeople of Mossville have experienced exposure to dioxin which has been shown to cause cancers, respiratory illnesses, and disruption to endocrine systems (Hines, 2015). In Flint, Michigan, the city’s water infrastructure was rerouted, and the new system contained lead piping that was shown to leach lead into the water. Lead is a known neurotoxin that can have particularly harmful effects in the developing brains of children (Hanna-Attisha et al., 2016). These cities are only two examples of communities that have suffered environmental racism. They serve as evidence of the necessity to raise awareness of this plight and to spark innovation for remedies to solve such inequities. In fact, Robert Bullard put it best “The de facto energy apartheid policy of “talking clean and acting dirty” hits African Americans and other people of color especially hard” (Lewis, 2016, p.7).

Environmental racism has not only affected African American citizens, but Native Americans as well. Members of the Ponca tribe in Oklahoma attributed their respiratory troubles to the emissions from a rubber compound manufacturing plant (Shriver & Webb, 2009). Indigenous knowledge has a foundation in the interconnectedness of all life, and honoring the valuable knowledge and insight of the connection to the natural world within our classrooms would enhance the learning of all students (Brayboy & Castagno, 2008b, 2008a; El-Hani & Souza de Ferreira Bandeira, 2008; Ryan, 2008). In addition to
acknowledging the knowledge of the Indigenous peoples whose land was taken from them by White settlers, it is necessary to acknowledge the racial discrepancy in those citizens who are more likely to suffer the ill effects of pollution of our resources. Investigating environmental racism in areas around schools would provide a prime opportunity to incorporate social justice into the classroom.

(3) Identifying sociopolitical context.

Societal issues that have conceptual connections to scientific content have been employed as frameworks for instruction termed socio-scientific issues (SSI). Presley et al. (2013) developed a framework for SSI-based curriculum founded on studying diverse classrooms using SSI. This framework provides four design elements for curriculum: (1) building instruction around a compelling issue, (2) presenting the issue first, (3) providing scaffolding for higher order practices, and (4) providing a culminating experience. The key component to the effectiveness of SSI is presenting the socially relevant issue first, prior to engagement with supporting activities and lessons, to hook students and capture their enthusiasm for the content. After scaffolding the student inquiry through engaging scientific exploration and discourse, students are given an opportunity to synthesize and apply their learning to the initial issue. In addition, students are encouraged to synthesize their learning to propose solutions or recommendations to address the presented problem. This full-circle process that starts with the issue and ends with students proposing potential solutions to this issue centers learning within a sociopolitical context.
(4) Allowing challenging discussions.

Often science lessons lend themselves to questions from students that center around race and ethnicity, particularly when studying content around genetics. Sheth (2019) proposed a science practice termed “grappling with racism” which “provokes teachers to critically engage with these contradictions that emerge from racism manifested in science and science teaching” (p. 55). Sheth is advocating for open and honest conversations in which students and teachers explore the historical and contextual situations which have resulted in instances of racial essentialism and environmental racism, to name just two. Morales-Doyle demonstrated centering AP Chemistry curriculum around environmental pollution with a focus on advocating for justice within students’ communities to improve achievement of urban students (Morales-Doyle, 2017; Morales-Doyle et al., 2019). Similarly, Taher et.al. (2017) demonstrated that the application of reality pedagogy, particularly through incorporation of the strategy of cogenerative dialogue (first developed by Tobin and Roth (2005)), provided opportunities for Latinx students to openly voice concerns within the science classroom. Sammel (2008) also described her personal journey through the various pedagogical strategies that led her to struggle and acknowledge White privilege and the ensuing challenging discourses that arose.

Children as young as elementary-aged are aware of and sensitive to issues of racial differences and discriminatory encounters, even though they may not have the words to explain these encounters. Ongoing conversations that address racism head-on and promote anti-racist attitudes are appropriate, if not difficult, for even early
elementary students (Boutte et al., 2011; Doucet & Keys Adair, 2013). In a diverse classroom setting that will approach content from a perspective of social justice, difficult conversations and potential microaggressions may arise. Microaggressions are the everyday, commonplace encounters that portray or perpetuate negative racial perceptions regardless of intention (Sue et al., 2009). In such settings, students found a legitimization in addressing the racial content and validation of feelings and perspectives helpful in countering issues of microaggressions and in pursuing discussions surrounding race. Students of color also observed that White students seemed to follow the emotional lead of the instructor: if the instructor was uncomfortable, students became uncomfortable as well (Sue et al., 2009). The benefit to a classroom with a diverse group of students is the minimized occurrence of colorblind interpretations of situations (Welton et al., 2015). However, before embarking on such challenging topics, teachers need to prepare. Washington and Humphries (2011) advise setting boundaries, anticipating worse-case scenario responses, and preparing questions to pose in response to student’s comments as topics of race are addressed.

**Socio-scientific Issues (SSI)**

The research demonstrates the efficacy of framing science instruction around sociopolitical contexts to engage and foster student learning through the use of socio-scientific issues (SSI) (Evren-Yapıcıoğlu, 2018; Sadler, 2004b). SSI instruction is founded on a framework of design that centers three-dimensional instruction around the social issue. This framework provides four design elements for curriculum: (1) building instruction around a compelling issue, (2) presenting the issue first, (3) provide
scaffolding for higher order practices, and (4) provide a culminating experience (Owens et al., 2018, 2018; Presley et al., 2013; Sadler et al., 2016b, 2019). The key component to the effectiveness of SSI is presenting an issue first, prior to engagement with standards-based, supporting activities and lessons to hook students and capture their enthusiasm for the content. Instruction is then curated to provide students opportunities to interact with science content using science practices to gather evidence and build a framework from which they will assess the initial SSI. Finally, students need an opportunity to synthesize and apply their learning to the initial problem and to propose solutions or recommendations relevant to the situation in the final culminating experience, thus connecting the learned content with the presented issue at hand.

Zeidler and Nichols (2009) argue that SSI provides an opportunity through argumentation and discussion for students to create their own understanding of scientific concepts, to assess prior misconceptions, and to apply science learning to relevant, controversial issues. Chowdury et al. (2020) identified ways in which SSI instruction can be used to promote specific aspects of citizenship such as social awareness, recognition of diversity in views, and student participation. Teachers found instruction through SSI provided a prime opportunity to engage students with content, but teachers needed to focus on content instruction with various perspectives and help students consider moral and ethical viewpoints (Bossér & Lindahl, 2019; Ekborg et al., 2013; Lindahl et al., 2019). SSI instruction focused on place-based situations were effective in activating the ethical and moral viewpoints. When students were given the opportunity to interact with ecojustice topics in a place-based setting, specifically the impact of wolf reintroduction in
Yellowstone to the surrounding community, students were encouraged to develop both emotive and empathetic reasoning (Herman et al., 2020).

**Nature of Science (NOS) and Socio-scientific Issues (SSI)**

To effectively decolonize science with a centering on social justice, incorporation of socio-scientific issues (SSI) with a focus on the nature of science (NOS) is essential. Nature of Science (NOS) encompasses the influences, procedures, challenges, and realities that are associated with the practice and conduction of science. Too often science is equated with impartial facts, devoid of prejudicial influence, but as humans are the practitioners of science this is far from the case. There are several components to NOS in the K-12 setting, ranging from seven (Lederman, 1999) to nine (McComas & Nouri, 2016) components. For this study, the seven tenets proposed by Lederman (1999) will be referenced:

1. Tentativeness of Scientific Knowledge
2. Observations and Inferences
3. Subjectivity and Objectivity in Science
4. Creativity and Rationality
5. Social and Cultural Embeddedness in Science
6. Scientific Theories and Laws
7. Scientific Methods

Clough (2018) has acknowledged that even though teachers may philosophically recognize the value of NOS in instruction, there are structural hurdles to contend with in
the implementation of NOS instruction: ineffective NOS incorporation in standards, lack of NOS incorporation in textbooks, and a focus on standardized testing, which often ineffectively assesses NOS skills (Cofré et al., 2019). However, in one Finnish study, Mutanen and Uitto (2020) found that more experienced preservice teachers put more value on NOS in teaching relevance of content matter to students. When teachers do teach NOS, some aspects, such as science is based on empirical data are more easily taught and learned, other aspects of NOS, such as tentativeness of science and the interactions of science with social and cultural aspects were more difficult to understand or less likely to be taught (Cofré et al., 2019). Centering instruction around SSI fosters a natural, compulsory discussion around tentativeness of science and social and cultural influences. Effective selection of SSI for instruction will provide opportunities to address NOS more effectively, particularly the more challenging components: tentativeness of science and social and cultural embeddedness. Careful selection of the socio-scientific issue is key in creating opportunities to address tentativeness of science and social and cultural embeddedness. Collaborative efforts to select SSI were more effective than those pursued individually (Hancock et al., 2019) as well as ensuring that the teacher maintained an honest awareness of their own limitations in pursuit of SSI with their students (Presley et al., 2013).

Science educators can begin to decolonize the curriculum through a shift to pedagogical approaches to science that acknowledge more than Eurocentric contributions and the use of curriculum that recognizes and faces the historical injustices scientific studies have been complicit in. Educators can also center science instruction on SSI and
face challenging conversations head on. This study will decolonize science curriculum through the framing of science curriculum around social justice socio-scientific issues.

**Voids in literature**

In the wake of the deaths of George Floyd, Breonna Taylor, and Ahmaud Arbery, young people became engaged in protests for racial justice that arose across the United States, and even around the world (Bryant, 2020). This mobilization of young people speaks to their engagement in social issues, particularly those of social justice and human rights. Rodriguez and Morrison (2019) critiqued educational studies that addressed equity, diversity and social justice and identified a need for more studies that explicitly name ways in which diversity and equity are leveraged toward social justice in science. Doğanay and Öztürk (2017), in an action research study, used human rights issues as a focus for SSI instruction in which 8th grade students in Turkey considered issues such as environmental protection, sustainable development, and organ donation. They found that students were able to consider issues that affected generations beyond their own and concluded by advocating for expansion of this strategy to other grade level students. In a longitudinal study of 249 underrepresented minority students majoring in science in college, Jackson and colleagues (2016) found that when students, particularly first generation university students, recognized their study of science could allow them to give back to their community they were more motivated to study science. While these studies used social justice as a framework from which to present instruction, there was no effort to determine whether students could use science to identify issues of social justice.
In light of this, I am curious if this prosocial attitude be utilized to engage and motivate students in their studies of science at the secondary level? This study proposes to attempt to decolonize the science curriculum through the lens of social justice centered socio-scientific issue instruction.

Social Justice in Science Instruction

There have been some attempts to implement social justice within science content. Morales-Doyle framed AP Chemistry instruction around the environmental justice perspective of a coal power plant pollution in the community of the school (Morales-Doyle, 2017). Lasker et al. (2017) present an overview of several curriculum resources that connect Chemistry content to social-justice framed issues; however, this curricula is geared toward post-secondary instruction. Even though there are resources that address race in terms of biological evolution, like that of the Howard Hughes Medical Institute (HHMI) Biointeractive website, there is no connection to social justice within the content or lessons (Bonetta, 2020). There is a void in the literature of social justice instruction within biology content particularly at the secondary level. The prospect of connecting SSI instruction with social justice issues is an appealing connection of a well-demonstrated pedagogical strategy with a seemingly captivating content for young people.

There are many opportunities to pursue social justice investigation within the biology curriculum. Rather than merely studying the structure and function of macromolecules that make up food (carbohydrates, lipids, and proteins), students can investigate how food deserts can affect overall health and lead to an increase in
underlying health conditions (Schafft et al., 2009; Testa & Jackson, 2019). Through this investigation there would not only be a study of macromolecules, but an examination of the underlying causes and connections to racial disparities (Testa & Jackson, 2019). Similarly, rather than simply discussing the structure of DNA and the technology by which DNA samples can be analyzed (South Carolina Standards: H.B.4B (Zais, 2014)), students can investigate the importance of this information to exoneration of wrongfully convicted persons (Mangan, 2004; O’Leary, 2012; Ruffins, 2011). Likewise, through this investigation, racial disparities may be brought to light through investigating the incidences of wrongful convictions.

**Study Summary**

The motivation of young people to become engaged with social issues (Bryant, 2020) along with the efficacy of SSI-framed instruction to engage students in discourse around a socially-relevant, challenging topic provides opportune occasion for instruction (Fowler et al., 2009; Owens et al., 2018; Sadler et al., 2006). With feedback from students, an action research plan was developed to capitalize on this intrigue for social justice and to guide students to connect classroom content to real-life, impactful issues that affect their community. This study will add to the literature through an investigation of incorporating social justice topics within an SSI framework in secondary science classroom.
Chapter 3: Methods

Introduction:

A decolonizing science curriculum was defined for this study as one that (1) highlights the contributions of Black, Latinx, Indigenous, and other underrepresented peoples to science, (2) acknowledges and addresses issues of historical injustices within science, (3) acknowledges and recognizes issues of sociopolitical context, and (4) does not shy away from challenging discussions and topics (Gorski, 2008). As discussed in Chapter 2, the science education research demonstrates the benefits of framing science instruction around socioscientific issues (SSI) to engage and foster student learning. It also describes the benefits of culturally relevant instruction of social justice related socio-scientific issues (SJSSI) used to teach and learn science content. (Ladson-Billings, 1995a, 1995b; Sadler, 2004b; Sadler et al., 2016b).

This research focused on students’ perceptions surrounding SSI around a social justice issue and its applicability to real-world scenarios. As the focus is student perceptions, observations of their interactions in class as well as their own characterization of the experience were primary sources of data. Additionally, their views and experiences were determined through focus group interviews and surveys before and after SJSSI lessons. Feedback from students were used to improve upon the process of incorporating social justice into the classroom. This study was centered on the following research questions.
Research Questions:

1. How do students characterize the connection of science to social justice issues?
2. How do students perceive their experience of learning social justice socio-scientific issues?
3. How do students describe the applicability of social justice socio-scientific issues to real-world contexts?

Methodological Approach

To address these questions, I conducted an action research project. The goal of action research is to change something, solve a problem, or take action (Glesne, 2016; Mills, 2018). The problem I was seeking to solve was to expand or deepen student recognition of the connection of scientific concepts in understanding social justice issues through refinement of my pedagogy. Action research was an appropriate methodology to use in this study because the goal was to refine my pedagogical and instructional strategies in order to expand/deepen student understanding through implementation of new instructional strategies (SJSSI).

First developed by Kurt Lewin, action research is designed to be a cyclical process of “planning, execution, and reconnaissances or fact finding” (Lewin, 1946). Lewin’s intention was that the problem-solving process be a group decision including input from those affected with regular reviews of progress (Adelman, 1993). Hammersley (1993) posited that teachers are appropriate researchers within their own classrooms because they have a comprehensive knowledge of the circumstances and history, an established relationship with the setting, and are able to enact change directly.
Three units that addressed issues of inequity were taught. Prior to the first unit students were surveyed to ascertain their perceptions of social justice. Within each unit of instruction students were presented with a scenario that required them to apply the content we were studying to examine the situation. Students were interviewed and surveyed again after participating in the lessons. Finally, they were asked to complete a reflection journal sharing their views of the learning experience.

Specifically, students were taught a unit on biochemistry (Leatherwood & Finneran, 2017) framed around health disparities that arise from living in food deserts (Schafft et al., 2009; Testa & Jackson, 2019). The class period prior to the unit, the students shared how they thought about the relationships between science and issues of disparity/inequity generally through completion of a survey. Upon completion of the second unit, studying the effects of living location on incidences of cancer, students were interviewed in focus groups and surveyed for their characterizations of their experiences with the unit, and descriptions of the connections that they are able to make between the science content and social justice issues. The feedback of the students was developed into an “action plan” as I developed the third unit on DNA situated in the occurrence of wrongful incarceration and the use of DNA analysis in exoneration. This cyclical process lead to the development of an action plan - or guidance - that other teachers can use to frame instruction around social justice.

Reflecting on my onto-epistemological perspective and the underlying framework that drives my thinking, this project was emic in nature. While I have a theoretical framework from which I view the ways students learn, the nature of the study was more
interpretive with a goal of seeking to understand. The ultimate goal of the study was to understand the students’ experience of learning from a social justice perspective in science and use this perspective to develop a framework for other teachers to use. All of these aspects came from a postmodern, interpretive approach that is more emic in nature (Glesne, 2016). Given this emic approach, students’ words, perceptions, and descriptions were used to modify and drive the direction of the action plan.

**Positionality.** I am a white, cis-gendered heterosexual female who was raised in a military, Catholic family. While I lived in several different locations during my upbringing, I primarily attended Catholic schools (from grade 6 onward) which were all primarily White in population. I also attended a primarily White university. In this study I was positioned as both teacher and researcher. As teacher, I had an established rapport and relationship with the students, while as researcher I attempted to review their comments and feedback as objectively as possible.

As a teacher I have made a commitment to practice culturally relevant pedagogy in my classroom. I approach the content I teach from a critical perspective, examining instances of scientific racism and including contributions of under-represented scientists. I also am the faculty sponsor for the first ever Black Student Union to be hosted at the predominantly white school where I teach.

**Setting Description**

This study took place in a secondary science classroom of a predominantly white Catholic High School in the southeastern United States. This location was selected because it was the school where I was teaching at the time of the study. Total population
of the school in 2021 was just over 490 students, almost 60% of whom were Catholic and the remaining students belonged to other faiths. The racial demographics of the school, as reported by families through enrollment forms, depicted a population that was 73% white, 14% African American, 7% two or more races, and the remaining 6% identified as Asian, Native American, or Pacific Islander.

The study consisted of four 9th grade Biology classes: two designated as college preparatory with an average size of 18 students and two designated as honors with an average class size of 25. College preparatory classes are designed to prepare students for a continuing education at a four year college. These courses ensure that they have competently mastered the objectives of the course standards and have the necessary foundation for further study. Honors courses demand a higher level of intensity and application in the course content. Students are expected to approach their content with more criticality and are required to demonstrate a level of application and synthesis beyond the college preparatory level. At the conclusion of the study there were 51 White students, 13 African American, 1 Asian, and 10 Latinx; the numbers did fluctuate slightly throughout the year as students entered and withdrew.

The content of instruction was based on the curriculum standards of the affiliated Diocese (Leatherwood & Finneran, 2017) and enhanced by the Next Generation Science Standards (NGSS Lead States, 2013) as the diocesan standards only provided basic content goals without a focus on science and engineering practices as the NGSS do.
Unit of Analysis

The unit of analysis for this study was the student experiences of refinements to the instructor’s instructional strategies involved in the social justice SSI lessons.

Role in Research

As is common in action research (Mills, 2019), my role in this study was twofold: (1) participant and (2) researcher. In the role of participant, my role was as the teacher implementing the social justice socio-scientific issues lessons. My role as researcher included gathering feedback, interpreting, and analyzing data. Both roles were combined to adjust and prepare for the next unit founded in social justice.

Data Collection

To answer to the research questions, an approach was taken that collected data from learners in multiple ways, details of which will follow. All four classes participated in the units of study. Initial surveys were administered in September 2021 and follow up surveys were administered in February 2022. Focus group interviews were conducted in January of 2022, and students were asked to reflect on the experience in April of 2022.

Surveys

Student Surveys. The first survey was administered to students during the class period prior to the implementation of the first social justice unit to provide insight into the views of the students on social justice and its relationship to science concepts (RQ#1 and RQ#3). This survey is presented in Table 3.1 and is the Basic Social Justice Orientation Scale (Items A – L) developed by Hülle et al. (2018) to measure the attitudes
of participants to equality, equity, need, and entitlement. Items C, K, and G address issues of equality; items A, E, and J address issues of need; items B, H, and I address issues of equity; and items D and L address issues of entitlement. I added items M – P to ascertain student views of the relevance of science to social justice components. Hülle et al. (2018) confirmed factorial validity of the assessment tool as well as established construct validity through comparison with the justice ideology scale which measures similar components.
### Table 3.1: Student Survey to assess social justice perspectives

<table>
<thead>
<tr>
<th>Item</th>
<th></th>
<th>Strongly disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>A society is just if all people have sufficient nutrition, shelter, clothing as well as access to education and medical care</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>B</td>
<td>It is just if hard working people earn more than others.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>C</td>
<td>It is just if all people have the same living conditions.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>D</td>
<td>It is just if members of respectable families have certain advantages in their lives.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>E</td>
<td>A society is just if it takes care of those who are poor and needy.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>F</td>
<td>It is just if people who have achieved good reputation and wealth profit from this later in life.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>G</td>
<td>A society is just if there are only minor income disparities between people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>H</td>
<td>A society is just if differences in income and assets reflect performance differences between people.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>I</td>
<td>It is just if every person receives only that which has been acquired through their own efforts.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>J</td>
<td>It is just if people taking care of their children or their dependent relatives receive special support and benefits.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>K</td>
<td>It is just if income and wealth are equally distributed among the members of our society.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>L</td>
<td>It is fair if people on a higher level of society have better living conditions than those on the lower level.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

**Open-Ended Questions**

<table>
<thead>
<tr>
<th>M</th>
<th>How are science topics important or useful to people in society?</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>How can science be applied or used to determine the needs of people in society?</td>
</tr>
<tr>
<td>O</td>
<td>How can science be used to identify inequities in society?</td>
</tr>
<tr>
<td>P</td>
<td>How can science be used to address inequities in society?</td>
</tr>
</tbody>
</table>

During the study, the survey was administered using Google Forms for uniformity in administration and for ease of distribution to students.
Student Group Interviews

Upon completion of the food desert unit, I conducted two student focus group interviews, one group interview was with students from the two college preparatory sections and the other group interview was with students from the two honors sections. Students were randomly selected from those whose parents consented to videoing. To complete the random sampling, I assigned each parental consent form a number as it was turned in, and then I used a random number generating software to select the students. Once I had the randomized list of students, I then reassessed the list to ensure comparable representation of gender and diversity across ethnicity. The first group interview with college preparatory students consisted of two white males, a Latina female, and an African American male. The second group interview with honors students consisted of eight students: four white females, two Pacific Islander males, 1 Latino male, and 1 White male. It is important to note that none of the parents of African American students in the honors sections (three males and three females) returned the informed consent forms.

The focus group interviews were a semi-structured format that began with the open-ended questions from the student survey presented in Table 3.1. The interviews provided a way to work toward saturation of data across classroom observations, survey responses, and member checking the views of the students. They also provided feedback for adjustments to the implementation of instruction.

The interviews were recorded using an iPad, transcribed using Temi© (Temi.Com, 2022) and coded for themes and recommendations to modify future units of
instruction. The first cycle of coding began with in vivo coding (Saldaña, 2016) where the students’ words dictated the themes: their definitions of equity and confusions with equality, and their hesitation with the concept of just. The second round of first cycle coding was value coding which considered the students’ views and perceptions of the social justice issues that were studied in class (Saldaña, 2016). The second cycle of coding was focused on pattern coding to parse out the themes from the students’ feedback which then informed the adjustments to the instructional units. Based on the patterns that arose the decision was made to include a mini lesson on definitions surrounding social justice issues as well as an inclusion of explicit instruction on issues of social justice and some the causes.

After the third unit of study, students were asked to complete a journal entry which was coded for thematic responses focused on student perceptions and reflections on the practice of studying biology with social justice issues as a whole experience. Students also completed the same survey from the beginning of instruction to determine if there were shifts in their perceptions.

Changes to methods

Prior to the implementation of the social justice unit of instruction, students were surveyed for their initial views of social justice issues as well as the connections of science content to those issues. While students were completing the survey, it became evident that there was confusion about some vocabulary; students were unsure of the use of the words “just”, “equity”, and “inequities”. In the post survey a clarifier was added to
further define “just”; for each use of the word just, a parenthesis was added to include (morally right and fair) (“Just,” 2022).

Focus group interviews further evidenced the vocabulary and terminology confusion. When students were asked what justice meant, they replied with answers like “good moral part”, “working for the right thing”, and “kinda like karma”. When asked to define equity, some students referenced the definition of equity in terms of finances, which was a misconception I did not anticipate. It was also during the focus group interviews that the students requested more explicit definitions of terms during lessons, particularly the distinction between equity and equality. In response to this request, I shared with them the image presented in Figure 3.1 (Maguire, 2016) that seems to have become ubiquitous and synonymous with equality vs. equity during the next class meeting. This image was used to facilitate a discussion as a class what it meant for things to be equal as opposed to equitable.

Figure 3.1

*Equality vs. Equity by Angus Maguire*
The clarifications of the terminology with the mini lesson addressing equity and equality as well as the parenthetical definitions of just led to fewer students responding with “I don’t know” in post surveys. I present the data in relation to how they support each of the research questions in the next Chapter. Pre-surveys were administered in the first two weeks of the school year (August 2021) prior to any unit that incorporated social justice. Post-surveys were administered early in the Spring semester (February 2022) after three units included topics of social justice.

After the focus group interviews it also became apparent that there was a lack of understanding about inequities, even after clarification of the definition. In an attempt to get students thinking about the underlying causes that can lead to wrongful convictions (unit lesson three), I shared with them a video from the Innocence Project about implicit biases (Innocence Project, 2018). The Innocence Project is a nonprofit organization that works to prevent wrongful convictions often through the use of DNA testing. (Innocence Project, 2022) This was followed by a discussion about what types of implicit biases exist and how that may lead to convictions.

Artifacts

Student artifacts. Student culminating experiences – final project of the SJSSI unit - were used in combination with interpretations of student views from observations and group interviews. Additional artifacts collected were student reflections that were gathered after the final unit in April 2022, samples of which are provided in the Appendices. The work the students produced as well as their reflections provided
evidence of their ability to connect the science content to the social justice issue and provide data to answer RQ#1 and RQ#3.

**Data Analysis**

**Surveys**

**Student surveys.** Student survey responses were collected using unique identifying codes to maintain anonymity and confidentiality. Responses were aggregated based on the social justice perspective coded for by the creators (Hülle et al., 2018). Overall mean scores were assessed for changes from pre- and post-unit administration. Items stated in the negative were reversed prior to determining means (Weinburgh & Steele, 2000). With more than 50 students involved in the study, a Wilcoxon ranked test was applied to pre- and post-unit survey results and provided data to answer RQ#1 and RQ#3.

**Interviews**

**Student Group Interviews.** The interview process was conducted in focus groups and recorded using an iPad for videoing. Interviews were transcribed using electronic transcription software (Temi.Com, 2022) and then coded to determine themes. In vivo coding, or coding using the participants own words, was the first cycle of coding for the focus group interviews (Saldaña, 2016). In vivo codes provided an insight into how students experienced studying social justice SSI and how they interpreted terminology from the lessons. It quickly became evident that students had difficulty
distinguishing between equity and equality and that some interpreted equity in terms of its financial definition.

A second round of first cycle coding was used to ascertain experiences and characterization. I chose value coding to determine the participants’ points of view (Saldaña, 2016). Value coding is coding for values, beliefs and/or attitudes. For example, when I asked the group “knowing science, can that help us tackle issues of equity or issues of justice for people in society?” and one student responded, “like an even distribution of vaccines”. This student was connecting response to the COVID-19 pandemic to equity in communities.

Pattern coding was selected as the second cycle of coding. Pattern coding is a collection of inferential codes that represent emerging themes (Saldaña, 2016). Student responses were grouped into themes around misunderstandings, applications, and recommendations.

As interviews were coded, I became aware that students were having difficulty connecting the content that we studied in class directly to the issues presented. This provided feedback that scaffolding support or explicit instruction of the social justice issues was needed to help students connect the content to the issues.

**Student Artifacts**

Student artifacts consisted of the culminating SSI assignments for two of the units; lesson two responses were not scored due to frequent quarantines during an omicron variant outbreak and a weather-related school closure during this time.
Additional artifacts include student responses to open-ended questions related to social justice in the pre- and post-survey as well as the student journal responses at the culmination of the lesson experiences. These artifacts were evaluated and used to provide support in answering all three research questions. In coding of student work, I was looking for evidence that students could make a connection between scientific content and the issue of the unit. Student work samples were assessed using the Likert-scale rubric provided in Table 3.3. The mean of student scores were collected and compared using a Wilcoxon signed rank test to determine if there was a significant change in scores from lesson one to lesson three.

Table 3.3

<table>
<thead>
<tr>
<th>Student work assessment Likert-scale tool</th>
<th>Lesson One: Food Deserts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student work connects science content to the focus issue of the unit</td>
<td>Students needed to discuss (1) a specific health condition that could be connected to poor nutrition, refer to specific macromolecules within foods, and connect those macromolecules to nutrition</td>
</tr>
<tr>
<td>Strongly Agree</td>
<td>Students needed to discuss (1) specifically who was affected (referencing either groups of people or living locations), (2) why they were affected (based on healthy food options), and (3) how they were affected (through food availability options)</td>
</tr>
<tr>
<td>Agree</td>
<td>Student response includes all but one of the components for level 5</td>
</tr>
<tr>
<td>Neutral</td>
<td>Student response includes only one of the components from level 5</td>
</tr>
<tr>
<td>Disagree</td>
<td>No mention of macromolecules but relative mention of health without referring to a specific condition</td>
</tr>
<tr>
<td>Strongly Disagree</td>
<td>Attempted a description but missed the focus of the issue.</td>
</tr>
<tr>
<td></td>
<td>Incorrect connection to science – mentioned a different issue not based on macromolecules</td>
</tr>
<tr>
<td></td>
<td>Did not connect to any issue related to complications or risks of COVID</td>
</tr>
</tbody>
</table>

Lesson Three: DNA Exoneration
| Strongly Agree | Students needed to discuss (1) DNA testing, (2) the uniqueness of DNA in individuals, and (3) the matching of patterns from the DNA testing gel electrophoresis results (either through a visual or in text) | Students needed to (1) discuss who was convicted, (2) why they were accused, and (3) include how they were wrongfully convicted. |
| Agree | Student response includes all but one of the components for level 5 | Student response includes all but one of the components for level 5 |
| Neutral | Student response includes only one of the components from level 5 | Student response includes only one of the components from level 5 |
| Disagree | No mention of DNA testing or unique patterns | Attempted a description but missed the focus of the issue |
| Strongly Disagree | Incorrect connection to science – mentioned a different issue not based on DNA testing | Did not connect to any issue related to wrongful convictions |

**Validity**

As the person who coded and analyzed the interviews and observations through the lens of my personal experiences, I needed to take care to ensure the validity of the findings as best I could. As Patti Lather (1986) said: “[t]he development of data credibility checks to protect our research and theory construction from our enthusiasms, however, is essential in our efforts to create a self-reflexive human science” (p. 67). In my study design I planned for validity checks in two specific ways: face validity and outcome validity.
**Face Validity**

The first validity check was face validity, or member checks, and this was accomplished through the focus group interviews. Face validity allowed me to check back in with participants to determine if my impression of survey outcomes and perceptions in class were correct (Lather, 1986). The focus group interviews confirmed my impressions that students were having difficulty with terminology, but the connection to financial equity was one I had not anticipated.

**Outcome Validity**

The goal of action research is to develop action-oriented outcomes. To validate that this study is attaining these goals, outcome validity was employed (Herr, 2015). To achieve outcome validity, I reflected with students in the focus groups to get their feedback to implement in subsequent units. After making adjustments, I gathered student feedback again through a journal response in which they provided their perceptions of studying social justice in a science classroom. The ultimate outcome provided me with data for refining methods for teachers to develop their own SJSSI unit.

**Reflexive Subjectivity**

I used analytic memos to track my interpretation of data, reflexively engaging with data in an iterative process at each stage. In addition, I sought feedback from two science teachers to review the scoring of student work on the Likert-scale (Table 3.3) of 20% of the student work samples. There was a difference of assessment on two of the assessments, and we came to consensus on the scoring.
**Member Checking**

As described under outcome validity, I engaged in member checking by when I shared back with my students the themes I determined from their feedback from student group interviews. I described that students requested explicit instruction of vocabulary terms related to inequities. I also reported back to students that more relatable or specific scenarios would be incorporated to illustrate the issues of social justice within the scientific context.

**Ethical considerations**

**Consent.**

I did not anticipate any ethical concerns; however, I did send home an informational letter to the parents and students explaining the action research and asking their consent to record the students during lessons and interviews (see Appendix A). Parents who agreed to have their children participate in the group interview process returned consent forms in August of 2021. In the two honors classes, none of the six African American students returned consent forms from their parents; therefore, they were not included in the group interviews, but were included in survey and assignment collection.

**Confidentiality.**

Videos of students were used only for transcription of focus groups and have not been shared with anyone else. They will be deleted at the conclusion of the project. In addition, students submitted surveys with coded identifiers so that I was unaware of
which student corresponds to which identification code, but I was able to compare surveys of individual students before and after lessons. All files with student information and videos of students were maintained under password protection to prevent breach of confidentiality. Permission was obtained from the school in May of 2021, the semester prior to implementation of the study. Institutional Review Board (IRB) approval was submitted in July of 2021 and approved early September 2021 in accordance with University expectations for studies involving students.
Chapter 4: Findings

Introduction:

The purpose of this study was to decolonize science curriculum through the incorporation of social justice issues to focus Biology instruction. Four private high school ninth grade Biology classes participated in three separate units that included social justice topics of focus. Those topics included: food deserts during the study of macromolecules, cancer alley during the study of cell cycles, and DNA testing used in exoneration of those wrongfully convicted during the study of DNA structure and protein synthesis.

Research Questions:

1. How do students characterize the connection of science to social justice issues?
2. How do students perceive their experience of learning social justice socio-scientific issues?
3. How do students describe the applicability of social justice socio-scientific issues to real-world contexts?

A summary of the data sources used to answer the research questions is provided in Table 4.1.
Research Question 1: How do students characterize the connection of science to social justice issues

To answer this question, I assessed student responses to open-ended questions within pre- and post-surveys, as well as student work samples. I will start with survey data and conclude with student work samples.

Each of the surveys (pre and post) contained four open-ended questions for students to complete. The responses to the first two questions (questions O and P) will provide evidence for research question #1. The questions from the survey are:

Question O: How can science be used to identify inequities in society?

Question P: How can science be used to address inequities in society?

Pre-Survey Results.

Seventy-six students across four classes completed the pre-survey, which was given the class period before the first social justice unit was taught. For the two questions listed above 32 of the students responded with some version of “I don’t know” to Question O, and 37 answered the same to Question P. As mentioned in Chapter 3, confusion about the meaning of the word equity may have played a role in the answers of...
“I don’t know”. An example of the misunderstanding of equity was a response to Question P of: “In science you can get a job that raises your equity”. Through an analysis of the remaining responses, three broad categories emerged: Research/Data, Basic Needs, Social Implications/Needs. Frequencies of students’ responses to the pre-survey are presented in Table 4.2.

**Table 4.2**

*Frequency of responses for coding variables to pre-survey questions O and P*

<table>
<thead>
<tr>
<th>Question</th>
<th>“I don’t know”</th>
<th>Research/Data</th>
<th>Basic Needs</th>
<th>Social Implications / Inequities</th>
</tr>
</thead>
<tbody>
<tr>
<td>O: How can science be used to identify inequities in society?</td>
<td>32</td>
<td>14</td>
<td>7</td>
<td>10</td>
</tr>
<tr>
<td>P: How can science be used to address inequities in society?</td>
<td>37</td>
<td>12</td>
<td>9</td>
<td>8</td>
</tr>
</tbody>
</table>

**Research/Data.** In response to Question O: “How can science be used to identify inequities in society?” 14 students responded with answers that were coded as research/data and in response to Question P: “How can science be used to address inequities in society?”, 12 students’ responses were coded into this same category. In their answers, students referenced practices involved in the act of “doing” science. They may have focused on the literal aspect of the question in terms of how science is done rather than the connection to identifying inequities. Most of these responses referenced data, statistics, graphs and other tools used in presenting or gathering data. Some of the responses to this question are presented in Table 4.3.
Table 4.3  
Student responses coded as research/data

<table>
<thead>
<tr>
<th>Example responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Using graphs and polls can help show the difference between groups of people</td>
</tr>
<tr>
<td>With statistics and observation</td>
</tr>
<tr>
<td>By using data gathered from the population</td>
</tr>
<tr>
<td>Observing data from that society and finding them</td>
</tr>
<tr>
<td>Facts they need for people to take their evidence seriously</td>
</tr>
<tr>
<td>By getting results then looking at actual fact and telling people facts</td>
</tr>
</tbody>
</table>

**Basic Needs.** The second category that was coded was basic needs (Question O = 7, Question P = 9). The responses that fell within this coding included more generic statements from students. Statements referenced “help” in general, “discovering what people need”, and “health and doctors” for the first question. To the second question, students again answered “health” but also answered “medicine”, “medical reports”, and “longer and healthier lives”.

**Social Implications/Inequities.** Finally, 10 students provided responses to Question O and eight students provided responses to Question P that fit within the category of Social Implications/Inequities. While students referenced issues such as “which group has the most advantage”, “determine who is more in need”, “provide a context”, and “so everyone can get an equal amount of benefit”; these responses were still vague and did not include specific aspects of either inequities or science.
Post-Survey Results.

The same survey was repeated after the second unit of instruction and after focus group interviews. Of the 66 responses to the post survey, 14 students answered “I don’t know” to question O and 24 answered the same to Question P. The responses for the post survey fell into the same categories as the pre-survey and frequency of responses are presented in Table 4.4. The most noticeable shift in response was the increase from 10 to 21 students who discussed either social implications or inequities in their response to Question O: “How can science be used to identify inequities?” Students had more specific responses in the post-survey than they did in the pre-survey.

Table 4.4

Frequency of responses for coding variables to post-survey questions O and P

<table>
<thead>
<tr>
<th>Question</th>
<th>“I don’t know”</th>
<th>Research/Data</th>
<th>Basic Needs</th>
<th>Social Implications/Inequities</th>
</tr>
</thead>
<tbody>
<tr>
<td>O: How can science be used to identify inequities in society?</td>
<td>14</td>
<td>19</td>
<td>4</td>
<td>21</td>
</tr>
<tr>
<td>P: How can science be used to address inequities in society?</td>
<td>24</td>
<td>12</td>
<td>9</td>
<td>9</td>
</tr>
</tbody>
</table>

Social Implications/Inequities. In the post survey responses to Question O, 21 student responses were coded as social implications or inequities. Six of the responses coded in this category referenced topics that were studied in the two social justice units taught prior to administration of the post-survey. Those responses are presented in Table 4.5
Table 4.5
Sample responses from students that reference social justice units

<table>
<thead>
<tr>
<th>Referenced Food Desert Issues</th>
<th>Referenced Cancer Alley Issue</th>
</tr>
</thead>
<tbody>
<tr>
<td>The types of foods in grocery stores around low income communities</td>
<td>Quality of environment</td>
</tr>
<tr>
<td>Cannot afford food or cannot afford to travel to get food</td>
<td>Flaws in living conditions</td>
</tr>
<tr>
<td>Communities are lacking from their base needs</td>
<td>Determine how bad some places are due to situations</td>
</tr>
</tbody>
</table>

While there was an increase in social connections to science in response to Question O, there were only 9 responses coded into the theme of social connections to Question P (How can science be used to address inequities in society?) in the post-survey, as compared to 8 in the pre-survey. These remaining responses fell into the themes of helping others and fair healthcare; sample responses are presented in Table 4.6.

Table 4.6
Sample responses from students that reference helping others or fair health care

<table>
<thead>
<tr>
<th>Helping Others</th>
<th>Fair Health Care</th>
</tr>
</thead>
<tbody>
<tr>
<td>It can help to change thing that are wrong</td>
<td>Rich have better healthcare than the poor</td>
</tr>
<tr>
<td>They can address who needs help in the world</td>
<td>Like some bad or good cells</td>
</tr>
<tr>
<td>To help people understand why some people need more help than others</td>
<td>How some people are better physically and how healthy people are</td>
</tr>
<tr>
<td>Discover how dangerous and of what concern certain equities are in society</td>
<td>Show which groups/people in society have better health and which have worse</td>
</tr>
</tbody>
</table>

65
Summary of Survey Responses.

From the open-ended survey responses, there was an increase in students who were able to describe or identify connections between science knowledge and identification of inequities in society. The survey responses provided more examples of student responses about using science to gather data to determine inequities among peoples in different communities: “identify the inequities in society by the statistics of health and etc of minorities or people who are targeted”.

Student work Samples.

I taught three units centered around social justice issues. The first unit was centered around the question: “How does access to healthy food contribute to underlying conditions that can lead to heart disease within the United States?” This question was incorporated into the study of biological macromolecules (carbohydrates, lipids, and proteins) and their functions within organisms. The second unit of study was centered on the question: “How does where a person lives increase their risk of cancer?” This question was central to the study of cellular division and regulation. The third unit of study asked the question “How can DNA be used to solve issues of wrongful incarceration?” This topic was incorporated into the study of DNA structure, protein synthesis, and the process of DNA testing through gel electrophoresis. All three of these units addressed the content of the biology instructional standards developed by the state.

At the culmination of each unit, students revisited the driving question and were asked to synthesize what they learned in terms of the social justice issue. For the
culminating project of the macromolecule unit, students explored what a food desert was, the experiences of one woman in Washington DC living in a food desert and investigated food deserts in our area. Students were then posed the following prompts (Appendix B):

1. Let’s look at this from a biological perspective. Why would food deserts lead to greater incidences of obesity? Make a claim, support with evidence, and provide reasoning.

2. Now, let’s connect this to inequities among communities. Knowing this information, and what you read/watched, consider the occurrences of pre-existing conditions that may make some communities at a greater risk of complications due to COVID-19. Make a claim, support with evidence, and provide reasoning.

The culmination of the cell division unit of study had students exploring the experiences of citizens living in “Cancer Alley”, Louisiana. They watched a video recounting the experiences of the citizens of Louisiana and their efforts to confront the chemical manufacturing plant (CBS News, 2019), read a news article that focused on one neighborhood that had been affected by air pollution from neoprene manufacturing plants along a section of the Mississippi River (Zanolli, 2020), and then were tasked with applying the science concepts to the experiences of the residents through letters to Louisiana legislatures posing possible solutions to the concerns of the citizens. A sample of the assignment is found in Appendix C. Responses from the second lesson were not analyzed as this assignment fell during a time of inclement weather closing and frequent quarantines due to the omicron variant of COVID-19. Because students were not present consistently during this point of instruction the assignment was not collected. Students
did not have the opportunity to engage in a class or a group discussion about the consequences of the pollution in Louisiana. However, it is evident that this scenario impacted students as they referenced this unit of study in their responses to the post-survey open ended prompts and to the journal reflections.

In the third unit, student groups of three to four members were tasked with selecting an individual who had been exonerated by the Innocence Project (Innocence Project, 2022). They had to prepare a poster describing the case, discussing the social justice issue, and connecting their study of DNA and DNA testing to how the wrongfully convicted were exonerated. Both assignments were scored using the Likert-scale tool presented in Chapter 3 (Table 3.3). A sample of the assignment is found in Appendix D.

In lesson one (food deserts), to earn a score of 5 for connecting science content to the focus issue of the unit, students needed to discuss a specific health condition that could be connected to poor nutrition, refer to specific macromolecules within foods, and connect those macromolecules to nutrition. To earn a score of 5 for clearly describing the social concerns of the issue for the same lesson, students needed to discuss specifically who was affected (referencing either groups of people or living locations), why they were affected (based on healthy food options), and how they were affected (through food availability options). For the assignment on DNA exoneration (lesson 3), to earn a five for connection to science content, students needed to discuss DNA testing, the uniqueness of DNA in individuals, and the matching of patterns from the DNA testing gel electrophoresis results (either through a visual or in text). In this same assignment, to earn a five for the description of the social issue, students needed to discuss who was
convicted, why they were accused, and include how they were wrongfully convicted. Several of these cases included false testimony, bias in witnesses, or incompetent attorneys or forensic scientists (Innocence Project, 2022). Student work for lesson 2 (cancer alley) was not analyzed as this assignment fell during a period in which school was closed during inclement weather and several students were absent due to quarantine from COVID-19 exposure.

**Student Work Analysis.** There were 37 students for whom I had work samples for both the food desert and DNA exoneration lessons. Specific samples of student work are presented later in Figures 4.3 – 4.6. The scores were compared using the Wilcoxon signed rank test using R Studio®. Results of the analysis are presented in Table 4.7. The frequency of score distributions are presented in Figures 4.1 and 4.2. The analysis demonstrates that there was a significant change in student ability to connect the science content to the focal issue of the lesson from lesson 1 to lesson 3. Mean scores of student work shifted from neutral/agree to agree/strongly agree on the Likert-scale in terms of their ability to connect the focus issue to science content. This shift demonstrates students’ abilities to connect the science content of study more thoroughly to the presented social justice issue. There was also a shift in mean scores from neutral/agree to agree in students’ abilities to describe the social concerns. This shift indicates an improvement in students’ abilities to identify and explain some social concerns that are present within our society.
Table 4.7  
*Comparison of student work samples in Lesson 1 and Lesson 3*

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Mean Lesson 1</th>
<th>Mean Lesson 3</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connect science to focal issue</td>
<td>37</td>
<td>3.65</td>
<td>4.35</td>
<td>0.003*</td>
</tr>
<tr>
<td>Description of social concerns</td>
<td>37</td>
<td>3.51</td>
<td>3.95</td>
<td>0.04*</td>
</tr>
</tbody>
</table>

*p-value < 0.05

Figure 4.1  
*Frequency of scores achieved in Lesson 1 and Lesson 3 in the category of connection to science*
Figure 4.2
Frequency of scores achieved in Lesson 1 and Lesson 3 in the category of description of social issue.
Figure 4.3
Student work samples from lesson one demonstrating connection to science at various score levels

Through the analysis of the artifacts, students showed a significant increase in their description of social concerns from lesson 1 to lesson 3 and in their connections of the science content to the social justice issues. In lesson 1 (food deserts), students’ connections to science most often were in relation to the consumption of unhealthy as opposed to healthy foods or access to healthy foods, often neglecting to include a
discussion of the biological macromolecules and their impact on the health of the food, which was our focus of study. An example of this is presented in Figure 4.3, score of four. Only one student specifically referenced the investigation we conducted on a cheeseburger kid’s meal during which we did not detect protein, Figure 4.3, score of five.

In this study, students conducted investigations and then were asked to apply those experiences as evidence to justify how science can be used to identify and address social justice issues. In the first unit of study, students conducted an investigation to detect the presence of macromolecules in a typical fast food kid’s meal. In their investigation, they were unable to detect protein in a meal containing a cheeseburger, apples, French fries, and a soft drink. They were asked to use this information to justify concerns in food desert areas. One student’s artifact demonstrated: “Food deserts would lead to obesity because of the lack of healthy food required to rely on fast foods which have a lot of saturated fats. Fast food is [sic] not have protein which is necessary for the development of muscles.”

In lesson one, 25 of the students’ descriptions of the social issue discussed the prevalence of health concerns when people ate more convenience foods. Eighteen of the 37 students did not make connections between peoples’ health conditions to the location of residence that lacks fresh, accessible foods and 13 of the 37 students did not include which groups of people were more likely affected by these areas. Three students discussed the social issue in terms of COVID-19 safety measures of using masks or disinfecting, which were unrelated to the underlying health considerations that we were studying, but a definite reality of the times we were living through.
In the first unit, students generally referred to foods that were unhealthy but did
not include a discussion and explanation of the science behind why the foods were
unhealthy, neglecting to discuss the macromolecules being studied:

The cause and effect leading to obesity in commonly known poor, lower income,
or racial aspects is food deserts. Food deserts typically are in these lower income
neighborhoods. Food deserts do not provide those with healthy fresh options,
rather they have the cheaper version in convenience stores and fast food. (student
work sample)

Students may have assumed that the why aspect of the health of fast food was understood
because it is a more commonplace discussion, although three students referenced organic
foods in discussion of healthy options even though we never discussed organic foods.
However, this underscores the need for scaffolding in discussion; I needed to be more
explicit in drawing out student explanations.

In the third lesson, DNA exoneration, students improved in their explanations of
the science that allowed for exoneration. Students discussed DNA testing and matching
crime scene DNA to the accused person. Several students incorporated a visual depiction
of DNA testing results to indicate the patterns of DNA and how they can be compared.

For the social issue involved in DNA exoneration, students were able to discuss
issues that led to wrongful incarceration and identified by what means the convictions
were obtained. This was an improvement in skill from the first lesson in that students
incorporated not only the real-world aspect of the issue but included a discussion and
explanation of the science behind how the DNA was interpreted for exoneration. For example, this student work sample scored a 5 due to the inclusion of DNA testing, discussion of pattern matching, and an image that depicted a sample gel electrophoresis DNA banding pattern to illustrate the uniqueness of the patterns.

William was exonerated through DNA testing. He was the 350th person to ever be so. He was exonerated on May 10, 2017. They tested the sperm on the victims [sic] jeans to the sperm of the actual assaulter and they were a match. (A sketch of a sample gel electrophoresis was included to illustrate the pattern matching).

**Student Work Samples.** The following figures are samples of student work from various scores on the student work Likert-Scale (1-5). Figure 4.3 is an image that includes the prompt given to students as well as screen captures of student responses that represent each level of scoring earned on the Likert-Scale. Student responses become more specific in their science explanation as the scores increase from two to five.

No students earned a score of one on this assignment, five students earned a two, and eight earned a three. The most common score earned was a four, with 19 students earning that score and only five students scored a five. The differences between scores of four and five are small. The score of four discussed that there are foods that are healthy and that the location has less access to healthy foods; this response was missing a discussion or reference to the macromolecules of study. In the response that scored a five, the same information from score four was included but also a reference to the macromolecules was also included.
Figure 4.4 provides screen captures of the second prompt and examples of student responses and their corresponding score assigned. No students earned a score of one on this assignment and five students earned a two. The most frequent score obtained for this prompt was a 3, with 15 students earning this score (Figure 4.2). This example is a typical response for that score: the student referenced the fact that the people most affected are found in poorer communities but did not include how they were affected or why they were affected.

In these examples, again, the difference between a four and a five are small but notable. In the response of four (ten students in total earned this score) there was a discussion of why (lack of healthy food options) and how (food availability), but what was missing was what groups of people or where food deserts are found. Only 19% of the students (seven of the 37) included all three aspects for the social issue.
### Figure 4.4
**Student work samples from lesson one demonstrating description of social issue at various score levels**

Figures 4.5 and 4.6 include photos of sections of posters prepared by student groups. Their assignment was to prepare a poster of a case in which someone was exonerated by the Innocence Project through DNA testing and answer the question: “How can science be used to address inequities, such as wrongful convictions, in society?” Figure 4.5 shows samples of work demonstrating representative scores for students’ connections to the science, and Figure 4.6 includes examples of student work.
for descriptions of social issues. The bold, red number on each image is the score assigned to the poster for the respective category.

For this last lesson, there were no submissions of student work that were assigned a one or two for connections to science, with the majority of the students earning scores of either four or five; 20 students scored four and 15 students scored a five, with the remaining two earning a score of three (Figure 4.1). This was an improvement as compared to lesson one work samples. Most often if a group did not earn a five it was because they discussed the DNA testing but did not discuss the pattern matching involved in the DNA testing and identification process. In the example presented in Figure 4.5, the group mentioned that DNA is unique to each person and that it was tested but did not discuss the pattern matching involved in the testing process that would rule out the wrongfully convicted person.

The handwriting for the level five sample is challenging to read. The students wrote:

Three hair samples were discovered on the sight [sic]. None of the samples matched Malcom’s so, the Innocence Project worked with the Jefferson Parish District Attorney’s Office to exonerate Malcolm. Malcolm was exonerated on January 30, 2018.

The Innocence Project used DNA testing of hair evidence to prove Malcolm’s Innocence. DNA testing is a long process that includes extracting the DNA
pattern from each sample. None of the hair strands match Malcolm’s so Malcolm is innocent [sic].

Figure 4.5
Student work samples from lesson three demonstrating connection to science at various score levels
Student work samples presented in Figure 4.6 are representative samples that demonstrate a description of the social issue in the lesson. Students often left out either how the conviction was obtained (e.g., bad forensics or false testimony) or they did not include why the convicted was accused in the first place. These issues are prevalent in wrongful convictions, and 14 of the 37 students successfully addressed all of the issues and were scored at a 5. In addition, 11 students earned a score of four, only because they left out why the convicted person was accused.
Summary of Student Artifacts. From the analysis of student work samples, there was an increase in students who were able to describe connections between the content knowledge that they were studying and the social justice issue that was the focus of their unit. Students were also better able to describe the social concern by digging a
little deeper into the underlying causes in lesson three as opposed to their ability to do so in lesson one as shown by the increase in responses that earned scores of four or five.

**Research Question 2: How do students experience studying social justice socio-scientific issues?**

To answer research question 2, I analyzed the Likert-scale items from the survey (pre and post responses) as well as coded the responses students journaled after completion of all units about their thoughts on studying biology using social justice issues for context. I will begin with survey data and conclude with the journal responses. Comparison of survey data shows changes in student perceptions of justice issues from before participating in social justice inquiry lessons and after participation. The social justice survey that I implemented is a Likert-scale survey from Hüle et al. (2018) with responses on a 5-point scale from strongly disagree (1) to strongly agree (5). The authors divided social justice into four perceptions: equality, equity, need, and entitlement and each area of justice was assessed using specific statements as identified in Table 4.8.

<table>
<thead>
<tr>
<th>Area of Justice</th>
<th>Questions relevant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equality</td>
<td>C, K, G</td>
</tr>
<tr>
<td>Equity</td>
<td>B, I, H</td>
</tr>
<tr>
<td>Need</td>
<td>A, E, J</td>
</tr>
<tr>
<td>Entitlement</td>
<td>D, F, L</td>
</tr>
</tbody>
</table>

For each participant for whom I had complete pre and post survey data, I took the average of their responses in each category for the pre-survey and the post-survey.
Therefore, the final data set had four variables for each student before the instruction, and four variables for each student after the instruction. The Wilcoxon signed rank test was applied using Rstudio® for each variable comparing the students’ mean before and after instruction perceptions. Result of the Wilcoxon signed rank test are presented in Table 4.9 and discussed below.

<table>
<thead>
<tr>
<th>Social Justice Principle</th>
<th>n</th>
<th>Before Mean</th>
<th>After Mean</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equality</td>
<td>35</td>
<td>2.61</td>
<td>2.95</td>
<td>0.03*</td>
</tr>
<tr>
<td>Equity</td>
<td>35</td>
<td>2.4</td>
<td>2.26</td>
<td>0.18</td>
</tr>
<tr>
<td>Needs</td>
<td>35</td>
<td>3.22</td>
<td>3.84</td>
<td>8.76x10^{-6}*</td>
</tr>
<tr>
<td>Entitlement</td>
<td>35</td>
<td>2.79</td>
<td>2.67</td>
<td>0.25</td>
</tr>
</tbody>
</table>

*p-value < .05

**Survey Justice Principles**

**Equality.** According to Hülle et al. (2018), the principle of equality refers to “the allocation of benefits and burdens is just if everyone is allocated the same share.” (p. 668). The following items from the survey were identified as statements about equality:

Item C: It is just if all people have the same living conditions.

Item K: A society is just if there are only minor income disparities between people.

Item G: It is just if income and wealth are equally distributed among the members of our society
Comparison of student responses on the pre- and post-survey indicate that there is a significant shift in perspective (p-value < 0.05). In the equality category, students shifted away from disagree/neutral toward the neutral category.

**Equity.** The principle of equity refers to “the distribution of benefits and burdens is just if the benefits and burdens in question are allocated according to individuals’ current individual contributions and efforts” (Hülle et al., 2018, p. 668). The following items from the survey were identified as statements about equity, the coding for the responses to these statements were reversed in accordance with the description in Hülle et al.:

- **Item B:** It is just if hard working people earn more than others.
- **Item H:** A society is just if differences in income and assets reflect performance differences between people
- **Item I:** It is just if every person receives only that which has been acquired through their own efforts.

The Wilcoxon comparison of equity items indicated that there was not a change in student perspectives before and after the unit of study. Students remained within the neutral/disagree range in both surveys.

**Needs.** “According to the need principle, benefits are allocated according to people’s individual needs” (Hülle et al., 2018, p. 668). The following items from the survey were identified as statements referencing need:
Item A: A society is just if all people have sufficient nutrition, shelter, clothing as well as access to education and medical care

Item E: A society is just if it takes care of those who are poor and needy.

Item J: It is just if people taking care of their children, or their dependent relatives receive special support and benefits.

The Wilcoxon results demonstrate a significant difference in student responses from before and after units of study. Students shifted from neutral to agree in the needs category items.

**Entitlement.** The final social justice principle that Hülle et al. (2018) incorporated into their survey was entitlement. According to the entitlement principle, benefits and burdens should be allocated on the basis of specific entitlements that are themselves based on ascriptive characteristics (e.g., social, origin, sex) or on status characteristics that have been acquired in the past (e.g., occupational status). The main difference from the equity principle is that benefits are not allocated according to individuals’ current contributions or efforts. (p. 668)

The following items from the survey addressed the principle of entitlement, again, the responses were reversed:

Item D: It is just if members of respectable families have certain advantages in their lives.

Item F: It is just if people who have achieved good reputation and wealth profit from this later in life.
Item L: It is fair if people on a higher level of society have better living conditions than those on the lower level.

Similar to the equity responses, there was no difference determined in before and after lesson surveys in terms of entitlement views from students; there was a slight decrease, but student responses still fell within the range of neutral.

**Student Journal Reflections**

After teaching the units that focused on food deserts, cancer alley, and DNA testing to exonerate those wrongfully convicted, I had students complete a reflection. The prompt the students were given was:

So far during this year, we have used topics that address equity and injustice in society. Some of the topics we tackled were: food deserts, cancer alley, wrongful incarceration and DNA testing. You have taken science every year and you may not have learned about issues like these within your science classes. Please describe to me what your thoughts are on studying science using topics like these. What did you like? What didn’t you like? Did it help you understand the information or give you relevance for what we were learning?

I was able to get responses from 78 students. Two of those students misinterpreted the questions and referenced liking labs and having difficulty with homework. Of the remaining responses the overwhelming majority (63 students) responded that they liked studying the material using these types of topics and that they found it helped them learn...
the material. However, there were eight students who disagreed, and five students who had emotional responses to the content.

**Students who had positive responses.** In 27 of the responses, students referenced specific units of study in their responses; as presented in Table 4.10, the majority of those referenced the wrongful incarceration unit as opposed to the other two (food deserts and cancer alley). More students who connected to or enjoyed the units that focused on cancer alley and wrongful incarceration more so than the unit that included food deserts. This may be because (1) more students have personal connection to experiences with knowing someone battling cancer and (2) the wrongful incarceration is a more sensational issue than healthy food options.

<table>
<thead>
<tr>
<th>Food Desert Unit</th>
<th>Cancer Alley Unit</th>
<th>Wrongful Incarceration Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>6</td>
<td>16</td>
</tr>
</tbody>
</table>

I coded the student responses with positive perspectives to studying biology using social justice. Within these responses, three themes emerged: liking the topic, relevance to real life, helpful in understanding concept. The frequency of responses coded within each of these themes is presented in Table 4.11.

<table>
<thead>
<tr>
<th>Mention of liking the topics</th>
<th>Mention of relevance to real life</th>
<th>Mention of helpful in understanding concept</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>14</td>
<td>23</td>
</tr>
</tbody>
</table>
**Liking the Topics.** A few themes emerged within the responses of students who simply mentioned that they liked learning with a theme of justice. Those themes are presented in Table 4.12 and represented a clarification of why they liked studying with these topics. Students liked learning about the injustices in our society and how they can apply what they learned to help their community.

### Table 4.12

**Themes of student responses within the coding category of “liking the topic”**

<table>
<thead>
<tr>
<th></th>
<th>Injustice/equity</th>
<th>Helping others</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>It helped me become more aware about inequalities and injustices</td>
<td></td>
<td>It relates these problems to something we understand and shows us ways that we can fix them</td>
</tr>
<tr>
<td>I really liked learning about equity and injustice because it’s real world problems</td>
<td>I liked learning how science can help discover and solve these problems</td>
<td></td>
</tr>
<tr>
<td>I am really happy that we are able to see how science is used in the real world and how we are learning about minority groups suffering and not just glossing over it.</td>
<td>Some of the things I didn’t know at all about and now that I do I could potentially help with them in the future</td>
<td></td>
</tr>
</tbody>
</table>

**Relevance to Real Life.** Students referenced that they appreciated studying content that related to real life scenarios. Students cited that learning how DNA testing allowed for freeing wrongfully convicted people was a real-life connection they enjoyed. A few of these responses are presented in Table 4.13.

### Table 4.13

**Student responses from journal entries**

<table>
<thead>
<tr>
<th></th>
<th>Enjoyed studying DNA testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>I want to be a forensic scientist, so learning about wrongful incarceration and DNA testing was really fun</td>
<td></td>
</tr>
<tr>
<td>I liked learning about DNA testing and how it improved to solve cases</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Real world issues</td>
</tr>
</tbody>
</table>
I like that it gives us a real world glimpse into what the world is really like
I liked having a reference for when the topic was used

A few students also mentioned that they found it interesting to learn that where you lived could affect your health (cancer alley), but far fewer mentioned enjoying the food desert unit. Student responses have led me to infer that the disconnect from the food desert unit could be either from the challenge of the content, studying biological macromolecules, or because cancer is a more relatable occurrence than food insecurity is for these students. One student mentioned that “I didn’t find food deserts as interesting”. Students would reference cancer alley and wrongful conviction units specifically but not the food desert units, further supporting the relatability of these topics over food deserts:

“I liked learning about DNA testing and how it improved cases”

“Cancer alley gave relevant information to the unit we were on”

**Helpful to Understanding.** Most students responded to the journal prompt that the issues we studied helped them understand what we were learning and did not go into more detail. A few, however, did elaborate. One student said that applying what we were learning helped him understand. Another student referenced that it allowed her to “dive” into the issue and research more about what we were learning. Finally, one student wrote “It made it easier and more interesting, so it made it fun”; he is the type of student who thrives when he is interested in a topic and engages more readily in the content.
Students who had negative responses. Of the eight students who did not wholly agree that using the social justice topics was engaging and helpful, three of them stated that it did not help them.

“I didn’t like that it did not exactly help me understand the lesson being taught”

“It is not helpful to understanding the topic”

“Nothing helped because I didn’t use anything to help me, I just gave up”

The third response may have been in reflection to her challenges in class overall, as she scored low on our first few unit tests and had to take advantage of reteaching opportunities throughout the academic year.

The remaining five students explained that they felt that studying food deserts was more appropriate for their human geography class, which also addressed food deserts as part of the curriculum.

Students who had emotional responses. I was expecting some potential concerns for two of my students who had parents battling cancer diagnoses when we studied the cancer alley topic. However, they were not the ones who referenced having an emotional response. Here are some quotes from the five students who had such a response:

“I didn’t like talking about cancer alley because it is very sad and I don’t like being sad”
“I disliked cancer ally [sic] because my cousin [sic] had cancer and it brought back bad memories from that.”

“I didn’t like that these things were happening to people and no one was doing anything”

“I didn’t like how [indecipherable] and that people are the cause for the problem”

“I felt bad for some of the people”

It is notable that of these five respondents, four of them indicated that despite the feelings, they still were able to find the concepts useful in understanding the information. The last respondent indicated “It didn’t help me understand because I had no idea what we were doing in the first place.”

In journal responses, these students claimed difficulty in seeing the connection:

Student 1: Discussing . . . these topics definitely added a level of depth and reality to the subject matter of biology. What I disliked about these topics was their distance from actual biology at times, not often feeling directly related to biology but instead coincidentally related.

Student 2: Overall I think that the topics are important but don’t really fit into the science category and really relate to anything in science.

However, in their work samples, they were able to effectively connect the content to the issue:
Student 1 describing the role of DNA testing in exoneration: DNA is unique and specific to each person, which was how Samantha was discovered as the attacker instead of Clemente from her DNA placement. Clemente’s DNA was also found, and only proved his innocence as only finding the bodies; the blood splatter on his clothing transferred when picking up the victims.

Student 2, describing the role of food deserts in the health of individuals: Food deserts can lead to greater incidences of obesity because the food that is easiest to get is high in carbohydrates and lipids, but low in proteins and other nutrients that humans need. Carbohydrates and lipids are macromolecules that can be bad for you if they are not consumed in moderation.

**Summary of Student Surveys and Journals**

The analysis of student surveys and journal responses provided evidence to answer Research Question #2: How do students experience studying social justice SSI? There was a shift in student perceptions of equality and needs in just societies. Student responses demonstrated that they became more aware of what qualified as needs of society and how societies can demonstrate more equality. Students also self-described that when they have a real-world situation to study, it helps them to understand the biology concept. Students also self-reported that they liked and appreciated learning about issues that affect and impact their community.

**Research Question 3: How do students describe the applicability of social justice socio-scientific issues to real-world contexts?**
To answer research question 3, the remaining two open-ended responses from the surveys will be used. The responses to the first two questions (questions M and N) will provide evidence for research question #3. The questions from the survey are:

Question M: How are science topics important or useful to people in society?

Question N: How can science be applied or used to determine the needs of people in society?

Pre-Survey Results

Seventy-six students completed the pre-survey. For the two questions listed above, I looked for themes among the responses given. The first thing that stood out right away was that 17 students answered a version of “I don’t know” to Question M and 19 students to Question N. Five other trends appeared among the responses to these two questions on the pre-survey: needs, knowledge, medical, application, and jobs. The frequency of responses under each of the coding categories are presented in Table 4.13.

Table 4.13

<table>
<thead>
<tr>
<th>Question</th>
<th>“I don’t know”</th>
<th>Needs</th>
<th>Knowledge</th>
<th>Medical</th>
<th>Application</th>
<th>Jobs</th>
</tr>
</thead>
<tbody>
<tr>
<td>M: How are science topics important or useful to people in society?</td>
<td>17</td>
<td>10</td>
<td>6</td>
<td>8</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>N: How can science be applied or used to determine the needs of people in society?</td>
<td>19</td>
<td>5</td>
<td>3</td>
<td>12</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>
**Needs.** For Question M, 16 students referenced “needs” in their responses. A typical response seen was “to determine the needs of people” with no further clarification, possibly prompted by Question N. Some students responded with different language but were still vague in their responses. Only 5 students referenced needs in responding to Question N. Some sample responses that demonstrate the vague responses to Question M were:

- “helps you understand important things we need in life”
- “things we need in life”
- “to know what you need so you know what to work for”

**Knowledge.** Six students referenced some sort of knowledge, learning, or understanding in answering Question M. These responses were centered around understanding how the world works. Representative answers were: “Science is important so that people know how the world works” and “Help people learn about things that can be useful”.

**Medical.** For Question M, 8 students responded with a reference to medicine or health; they identified finding cures, identifying illness, or even treating mental health concerns. But to Question N, 15 students made reference to health or medical issues. One specific quote that addressed the way science could be applied in determining needs of individuals addressed inequities with: “Different backgrounds and ethnicities are at different risk rates for sicknesses so some [sic] who is African American, may need more help with something than someone who is Hispanic”
Application. Seven students referenced applying scientific knowledge when answering Question M to develop new technologies, such as “inexpensive alternatives” or “solar-powered entertainment”. They also referenced using science to gather data: “using statistics gather from studying crime you can find the cause or motives of certain crimes”

Jobs. Three responses between the two questions referenced studying science in the pursuit of a career with responses such as: “They are useful if you study them and get a job from them”

Social justice connection. In the pre-survey, three student responses were particularly interesting in light of the focus of this study in that they touched on underlying causes of inequities in communities. In response to Question M one student answered: “Science topics are important and useful to people in society because it explains how and why we have certain things in our community.” To Question N, a student responded: “Different backgrounds and ethnicities are at different risk rates for sicknesses so some who is [sic] African American, may need more help with something than someone who is Hispanic.” Another responded to the same question with: “Science can be used for water treatment and stuff of that matter. Science is not helpful for determining ‘pay gaps’ in society.”

Post-Survey Results

Sixty-seven students completed the post-survey. After experiencing the social justice lessons, only 11 students responded “I don’t know” to Question M and to
Question N. For the post-survey, the five trends that emerged were: medical, social, argumentation, application, and knowledge/experimentation. Frequency of responses within each coding category are presented in Table 4.14.

**Table 4.14**  
*Frequency of responses for coding variables to post-survey student responses to Questions M and N*

<table>
<thead>
<tr>
<th>Question</th>
<th>“I don’t know”</th>
<th>Medical</th>
<th>Social</th>
<th>Argumentation</th>
<th>Application</th>
<th>Knowledge/Experimentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>M: How are science topics important or useful to people in society?</td>
<td>11</td>
<td>11</td>
<td>13</td>
<td>5</td>
<td>4</td>
<td>14</td>
</tr>
<tr>
<td>N: How can science be applied or used to determine the needs of people in society?</td>
<td>11</td>
<td>9</td>
<td>7</td>
<td>2</td>
<td>3</td>
<td>20</td>
</tr>
</tbody>
</table>

**Medical.** In the post survey, students referenced medical needs again, and the results were similar. For Question M, 11 students referenced medical needs in the post-survey as compared to 8 for the pre-survey. For Question N, the responses decreased in the post survey: 9 students in the post survey referenced medical connections, compared to twelve students in the pre-survey. Common themes around medical responses included diagnosis, disease research, and a deeper understanding of how our bodies work. Sample responses are presented in Table 4.15.
Table 4.15  
**Sample post-survey responses coded as medical to questions M and N**

<table>
<thead>
<tr>
<th>M: How are science topics important or useful to people in society?</th>
<th>N: How can science be applied or used to determine the needs of people in society?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Determine needs of people especially ones who are ill ex: cancer</td>
<td>determine the medical needs of people</td>
</tr>
<tr>
<td>understand diseases and life threatening things”</td>
<td>what kind of medicine some people need”</td>
</tr>
<tr>
<td>can identify the health conditions of people</td>
<td>doctors and checkups</td>
</tr>
<tr>
<td>understanding of how our bodies work</td>
<td>people who are sick should receive care</td>
</tr>
</tbody>
</table>

**Social.** Responses to the post survey showed a theme referencing equity, living conditions, and uneven distribution of resources. Student responses included using science to identify potential dangers in society, using science to get a better understanding of why there are differences for citizens, and studying factors harming low-income communities; examples of these responses are presented in Table 4.16.

Table 4.16  
**Sample post-survey responses coded as social to questions M and N**

<table>
<thead>
<tr>
<th>M: How are science topics important or useful to people in society?</th>
<th>N: How can science be applied or used to determine the needs of people in society?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Getting enough resources to live</td>
<td>make food for the needy</td>
</tr>
<tr>
<td>determine whether peoples living situations are tougher than others</td>
<td>how people cells are harmed by there [sic] environment</td>
</tr>
<tr>
<td>see what race and areas of the country are struggling</td>
<td>to find the perfect amount of support we can give to our citizens without becoming reliant</td>
</tr>
<tr>
<td>identify dangerous inequities in society and how we can fix them</td>
<td>identify problems with living conditions</td>
</tr>
</tbody>
</table>

**Argumentation.** In response to Question M five students referenced using science and data in “proving points” or winning arguments, examples are presented in Table 4.17. This demonstrated a recognition of having evidence to support claims and arguments
rather than just feelings or opinions. These responses also reinforced the focus of supporting claims with evidence that was prevalent throughout this class; my students regularly were asked to follow the CER (claim, evidence, reasoning) format in responding to investigations in class (McNeill & Krajcik, 2008).

**Table 4.17**

*Examples of student responses coded as argumentation*

<table>
<thead>
<tr>
<th>Examples of argumentation responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can back up people’s personal explanations</td>
</tr>
<tr>
<td>Prove people’s points</td>
</tr>
<tr>
<td>More facts that can be proven</td>
</tr>
<tr>
<td>Can help arguments end</td>
</tr>
<tr>
<td>Prove things</td>
</tr>
</tbody>
</table>

**Application.** In response to Question M, four students referenced applications that entailed making things better or easier, such as “make things cheaper”, “find solutions to problems”. In response to Question N, several of the responses referenced using the science to determine the needs of people in society: “show what they need” and “what resources are needed for society”.

**Knowledge/Experimentation.** Another new theme that appeared in the post survey was the use of science to collect data and continue with experimentation. Fourteen students answered with a response that was coded as knowledge or experimentation to Question M and 20 students answered similarly to Question N. Sample responses are provided in Table 4.18.
Table 4.1
Sample post-survey responses coded as knowledge/experimentation to questions M & N

<table>
<thead>
<tr>
<th>M: How are science topics important or useful to people in society?</th>
<th>N: How can science be applied or used to determine the needs of people in society?</th>
</tr>
</thead>
<tbody>
<tr>
<td>help you understand things with a better education</td>
<td>can help us understand people</td>
</tr>
<tr>
<td>understand the nuances of the natural world</td>
<td>it can give us statistics</td>
</tr>
<tr>
<td>help people better understand what’s going on in the world</td>
<td>give us information</td>
</tr>
<tr>
<td>they give facts</td>
<td>Helps people learn</td>
</tr>
</tbody>
</table>

Summary of Survey Results

The comparison of pre-and post- survey open-ended responses provided supporting evidence to answer Research Question #3: How do students describe the applicability of social justice SSI to real-world contexts? Immediately, there was a decrease in responses that included “I don’t know” which indicated more students were confident in providing a response to the connection of science to issues of social justice. In addition, the initial themes were primarily around learning about the world around them, medical applications, and needs of people. After studying the social justice units, students shifted in their themes and included identifying issues of injustice, gathering evidence to support arguments, and application of scientific concepts.

Shifts in Instructional Units

As part of the action research aspect of this study, pedagogical reflection and student feedback were used to make adjustments to the lesson format for the social justice units. During the first unit, the study of food deserts in context of biological macromolecules, it became evident that students needed support in making the
connections between the science content studied and the social justice issue. In the first lesson students understood that healthy food is important, but often neglected to connect that to the function of the various biological macromolecules in a person’s diet.

During the second lesson, studying cell cycling and the prevalence of cancer in those living in cancer alley, more time was spent discussing that the residents who were most affected along cancer alley were African American (James et al., 2012). While the students studied cell cycle checkpoints and how the cell checks for damage before proceeding through the division process, we discussed that some environmental factors could interfere with the cycle and the cell may reproduce while damaged. The choice of content also was a shift in the unit planning from the first to second units. The occurrence of cancer is a more personally relevant situation for the students than experiencing food deserts. While I believe it is important for students to learn about situations affecting people outside of their community, starting with a more relatable topic may have fostered a groundwork for making connections.

The focus group interviews took place shortly after the second lesson, and the feedback provided by students provided clarity for me in their understanding of terminology. It became quickly evident that some students were not clear about the distinction between equity and equality. It also became clear that those who did know there was a difference, a few were applying the financial definition of equity to our discussions. This made it clear that students may have been participating in conversations with an incomplete knowledge of terminology. Based on their feedback
and suggestions, I spent a little time defining for all classes the distinction between equity and equality. Again, explicit instruction became important for students.

Another challenge in nuanced language for the students arose from one of the survey questions. “It is just if all people have the same living conditions” was a survey prompt that gave the students pause; many were interpreting this to mean that people should have the same type of home or car. I had to include in class discussions that “same living conditions” referred to equal access to healthy food, water, and air. These conversations allowed us to reflect back on our studies of food deserts (access to healthy food) and cancer alley (access to clean air) and connect the living conditions to the health conditions that people encountered.

The topic for the final lesson also proved to be engaging for students. While students likely did not have a personal connection to wrongful incarceration, the use of specific cases of individuals who were wrongfully incarcerated gave them a purpose that motivated them to understand the topic of DNA and DNA testing. In my field notes I noted that one girl became teary-eyed while reading the cases of the wrongfully incarcerated people. When I asked her why she was sad, she responded that “they missed out on their lives.” Another student commented that this type of topic is interesting to her, and she wants to work in social justice, she even recommended the book Just Mercy to me.
Summary of Changes to Instruction

The changes to instruction that were implemented in this study were threefold. First, explicit instruction of definitions pertinent to understanding social justice issues. Second, a purposeful discussion of the nuanced meanings of needs within a community. And finally, incorporation of relatable, personal case studies as with the Innocence Project to study the application of DNA testing.
Chapter 5: Conclusion

Introduction:

This chapter presents a summary of the study and the themes that were revealed in student work, interviews, and survey responses as presented in Chapter 4. I will also situate the findings within the context of the literature and implications for classroom teachers. I will close this chapter with recommendations for further study.

This study has set out to address the issue of Eurocentric domination within science instruction by seeking a method of decolonizing the science curriculum. This study used Paul Gorski’s (2008) definition of decolonizing curriculum which focused on four key points: (1) highlights the contributions of Black, Latinx, and Indigenous peoples to science, (2) acknowledges and addresses issues of historical injustices within science, (3) acknowledges and recognizes issues of sociopolitical context, and (4) encourages challenging discussions and topics. The purpose of the study is to see what happens when I attempt to decolonize Biology instruction by framing instruction through a lens of social justice issues, focusing on the last two points of Gorski’s definition. The three research questions that drove this study are:

1. How do students characterize the connection of science to social justice issues?
2. How do students perceive their experience of learning social justice socio-scientific issues?
3. How do students describe the applicability of social justice socio-scientific issues to real world contexts?

**Major Findings**

The major findings of this study can be summarized into four areas. After participating in the social justice socio-scientific issue lessons:

1. Students were better able to describe how science can be used to identify social justice issues in society.
2. Students were able to describe the social concerns relevant to our units of study.
3. Students shifted in their perceptions of equality and in providing for the needs of citizens in our communities but did not shift their perceptions of equity and entitlement.
4. Students were engaged and enjoyed studying biology from a perspective of social justice.

*Students Describe How Science Can Be Used to Identify Social Justice Issues in Society.*

Student responses to the open-ended survey questions that asked, “How can science be used to identify inequities in society?” demonstrate a shift in their ability to describe how science can be used to identify social justice issues in society after participating in the three social justice lessons. Far more students (21) responded to the question with an answer that was coded as social implications in the post survey as compared to the 10 students who responded similarly to the pre-survey question.
Student responses in the pre survey were focused on gathering data about groups of people and determining fairness from the data; representative responses were: “Science can be used to identify inequities in society by accounting all aspects in societal life and going from there” and “It can show different struggles people have in different situations”. In the post survey student responses demonstrated an application of the content taught and an understanding that there are underlying causes to inequitable situations. Students included responses that described the issues of food deserts, a topic we studied: “the types of foods in grocery stores around low income communities compared to high income communities”. Some responses addressed living conditions and quality of the environment (relevant to cancer alley study): “Science can show and identify the inequities in society by exposing the flaws in living conditions, economy, government, population, etc [sic] which can help people to focus on the flaw”. Students also considered issues beyond our studies: “It shows if the rich have better healthcare than the poor” and “By looking at our genetic similarities and realizing we don’t need to treat people unjustly”. Finally, students also recognized that inequalities affect some races more than others: “to identify inequities in society by the statistics of health and etc of minorities or people who are targeted”

Researchers who have incorporated issues around justice within their studies have found that in order to classify an issue as a social justice science issue (SJSI) consideration needed to be given to how the students viewed the issue as relevant to their community (Morales-Doyle, 2017). Morales-Doyle found that an effective SJSI “grapples with issues of social justice as it intersects with scientific phenomena and
resonates with the hearts and minds of the students” (p. 1043). My students may have felt more removed from the issues of food deserts – none of them personally live within a food desert and do not have the limitations or food insecurities that their counterparts in some of the rural parts of our state may have. Levine Rose and Calabrese-Barton (2012) also found that with middle school students, the experiences of the students played a role in how the students framed or interpreted the issues. If students did not have a direct connection, teachers may need to guide students to practice framing issues of social concern through a variety of lenses: ecological, economical, health, to name a few. However, as I strive to decolonize my classroom and incorporate aspects of culturally relevant pedagogy, students benefit from the exposure and opportunities to learn about the cultural experiences of others, even if they can not relate themselves.

My students were able to connect more to the topics of Cancer Alley and wrongful convictions. Each of the students knows or has known someone who was affected by cancer (two of whom had parents diagnosed during our academic year together); these personal connections afforded them the ability to relate to and sympathize with the citizens of Louisiana. This was evidenced by the eight students who reflected on the cancer alley lesson in their journal responses, two of whom specifically discussed how hard it was to study cancer: “despite the bad memories it did help me understand the content”. In terms of the wrongful convictions, the stories provided by the Innocence Project gave my students a face, a name, and a description of that individual that allowed them to have empathy for their situation. Had we studied DNA testing without the context of a real individual who was exonerated, they may not have been as
connected or invested. Lundeberg and Yadav (2006) found that when case studies were used, students self-reported that the content was easier to achieve and that the higher the expectation of achievement, the greater the gains. This was further corroborated in a study of over 100 university science faculty that found when case studies were incorporated into their curriculum, students thought more critically and were better able to make connections to content being taught (Yadav et al., 2007).

**Students Describe Social Concerns Within Society.**

Culturally relevant pedagogy requires that teachers incorporate socio-political consciousness within the academic curriculum, focusing on place-based issues relevant to students’ communities (Ladson-Billings, 1995a). Morales-Doyle (2019) argues that ‘an equitable science education asks students to consider how they can use scientific knowledge to build collective power for peace, justice, and sustainability” (p.490) Reiss (2003) posits the necessity of including social justice issues in science instruction to broaden student interest and expand the focus of social justice beyond the classroom and to prepare students to apply their knowledge to the “real world” and not just for the next class they will take.

While these researchers argue that use of social justice content in science classrooms is valuable and essential, they do not discuss how students are able to describe those social concerns. After participating in three units focused on social justice issues, my students’ work samples demonstrated an improved ability to describe social concerns. Student responses to the open-ended survey questions that asked, “How are science topics important or useful to people in society?” and “How can science be applied
or used to determine the needs of people in society?” demonstrate their ability to describe
social concerns within society after participating in social justice lessons. The themes
that developed from responses to these questions prior to participating in the lessons
were: needs, knowledge, medical, application, and jobs. Responses in the pre-survey
were very general and lacked depth of application of the science component as
demonstrated by these sample responses: “helps you understand important things we
need in life”, “help people learn about things that can be useful”, “determine causes of
sickness”, and “help people make discoveries”. These responses lacked specificity and
reflected primarily academic and medical uses for science.

After participating in the lessons, the themes that were coded for the same
questions were medical, social, argumentation, application, and knowledge. There was a
greater sense of depth and application within these responses. Students began answering
the questions with specific scenarios: “can identify the health conditions of people”, “if
people are getting enough resources”, and “can back up people’s personal explanations”.
These responses show a greater understanding of the way science can be applied and
impact society beyond the typical responses of medicine and education.

In addition to recognizing a broader application of science, students recognized
the value of understanding science in argumentation. Argumentation is an essential skill
to developing scientifically literate students; use of socioscientific issues has been
demonstrated to be effective at developing argumentation skills, particularly when this
practice is supported and scaffolded (Dawson & Venville, 2010; Evren-Yapıcıoğlu, 2018;
Sadler, 2004b). The skill of using evidence-based arguments to support claims is a key to
the nature of science and of students with strong scientific skills. The use of SSI in the classroom is effective at promoting concepts of the nature of science such as the application of empirical evidence and the tentative nature of science (Eastwood et al., 2012; Sadler, 2004b). In this model of instruction, students are exposed to scientific experiences that require them to obtain empirical evidence to support claims that they apply to real-world scenarios. In the settings of social justice issues, students are faced with recognizing and reconciling with the fact that science is conducted within a social setting and is influenced by its cultural embeddedness.

In addition to survey responses, student work was assessed on a rubric that evaluated products for connections to science focal issue and descriptions of social concerns. Students’ abilities to connect science content to the focal issue scored a mean of 3.65 (out of 5) on the first lesson, but for the third lesson, their ability to connect was scored a mean of 4.35 (out of 5). Students were more effective at connecting the issue of exoneration to the process of DNA testing in their descriptions of the wrongful incarceration cases. This ability to connect the science to the focal issue in Lesson 3 was an improvement to the first unit in which students were able to connect health conditions to accessibility of healthy foods, but only a few (5 of 37) were able to connect to the biological macromolecule content of the foods that made them healthy or unhealthy.

Rudsberg et al. (2013) analyzed recorded SSI discussions in upper secondary schools and found that as learning progresses through the academic course, argumentation skills also improved. My students may have improved in their connections through experience of opportunities to practice.
Zeidler et al. (2013) implemented several surveys to students from five different countries in school grades equivalent to US grades 10-12; they found that students in South Africa, Jamaica, United States and Sweden had more difficulty in using their scientific knowledge in justifications of SSI issues than those students from Taiwan. They found that students from Taiwan exhibited more egalitarian perspectives than students from the other countries. This demonstrates that students within the United States may need support and guidance in extrapolating issues from individual perspectives to community perspective. For example, Sadler (2004) found in a review of literature that during SSI lessons students would apply evidence-based arguments but did not address counterpoints. Dawson and Venville (2008) found the need to scaffold and support the practice of argumentation. The SSI model of instruction lends itself readily to promoting the application of concepts of nature of science, such as argumentation and empirically-based evidence (Eastwood et al., 2012)

Student work for lesson one (food deserts) was scored on a scale of 1 to 5 with a mean of 3.51 in their ability to describe social concerns, and after all three instructional units, student work scored a mean of 3.95 on the same scale for their work on the DNA exoneration assignment. In the study of food deserts, students would discuss that eating unhealthy foods would lead to illnesses that would make them more at risk for complications due to COVID-19, but they did not discuss that access to the healthy foods because of living locations was a contributor to eating unhealthy options. In Dimick’s (2012), study of a public charter school’s investigation of pollution in a nearby river, not all students were able to connect the issue to the scientific concepts; many of them
needed additional scaffolding support in the academic context but were motivated to participate because of the justice-oriented issue. Similarly, many of my students were unable to connect the risks of limited access to healthy food to the scientific concepts of macromolecule function. My students had most experienced issues of food insecurity from a vantage point of an opportunity to provide service or donation. Each year the school promotes a school-wide food drive around Thanksgiving, but students do not have any connection to whom this donation benefits. Providing students with a case study situation (even if fictitious) in which a teenager lives in a food desert might give a sense of connection just as the individualized cases from the Innocence Project did.

However, as students described the social issue relevant to the wrongful incarceration, students were more able to include the who, why, and how involved. If students did not earn the full score of 5 on the assignment, it was often because they neglected to include why the person became convicted. They were effective at discussing who the convicted person was and how they were exonerated. This could have been improved through purposeful discussions in the classroom to consider which people were more likely to be convicted and why. At the start of that unit, I conducted a mini lesson on implicit bias, but, upon reflection, did not effectively refer back to implicit bias as students grappled with the reasons for wrongful convictions.

The opportunity to connect with the wrongfully convicted from an empathetic perspective may have resulted in a greater ability to connect the science to the issue and to describe the social concern. Empathetic connections within an elementary STEAM classroom resulted in greater ability to apply scientific concepts because the scenario was
not arbitrary, but rather, a purposeful and relevant investigation (Bush et al., 2020). Having the personal description from The Innocence Project may have humanized and provided an empathetic experience for the students’ learning motivation. Students can experience transformative learning as they are exposed to scenarios that expand their knowledge of human experiences and extend their frame of experience (Mezirow, 2009).

Powell (2021) found that middle school students were able to generate arguments effectively if SSI practices were implemented well in the classroom; students could discuss the factors involved in making decisions when given the social issue to investigate. My students focused on empirical evidence as the value of using science to identify social justice issues in society, just as Sadler found in his meta-analysis of SSI research as they relate to science education (Sadler, 2004b); students were able to apply content learned within the context of the SSI unit, but not necessarily able to extrapolate beyond the localized context. Sadler and Zeidler (2005) found that mastery of content was related to improved reasoning, but that context was important: genetics understanding was more adeptly applied than the influence of environmental factors on health conditions; they found that just because students had content knowledge, they did not always connect it to the SSI unless there was a more personal experience. This was similar to my findings; students experienced more personal connection to issues related to individual health and safety (cancer and wrongful incarceration) and were more effective at making scientific connections to these scenarios, as opposed to the localized issue of food insecurity, which was not relevant to my students.
Further, instruction of social justice issues needs to be explicitly made. Students studying social justice issues, just as in studying nature of science, need explicit instruction of social justice issues rather than assuming that they will make the connections implicitly (Abd-El-Khalick et al., 1998). Walker and Zeidler (2007) found that when students were given scaffolded experiences in applying their learning through SSI to specific aspects of NOS, then they were more successful at critically analyzing the issue. They proposed a guided experience of focusing on specific aspects of NOS within the context of the SSI. In instruction with social justice issues, scaffolding could be centered around the Learning for Justice Social Justice Standards (Chiariello et al., 2018). Within this framework of standards, there are grade-level standards divided into areas of identity, diversity, justice, and action. Just as Walker and Zeidler (2007) proposed focusing on specific areas of NOS connection, science students could focus connecting content to specific standards for social justice. The following three standards would have been appropriate for focus with my students:

Diversity 10 (DI.9-12.10): I understand that diversity includes the impact of unequal power relations on the development of group identities and cultures.

Justice 12 (JU.9-12.12): I can recognize, describe, and distinguish unfairness and injustice at different levels of society.

Justice 13 (JU.9-12.13): I can explain the short and long-term impact of biased words and behaviors and unjust prices, laws and institutions that limit the rights and freedoms of people based on their identity groups. (Chiariello et al., 2018)
Using the above-referenced standards would provide direction and a means of assessing my students’ understanding of social justice issues. For example, the first standard, Diversity 10, prescribes a specific way in which to approach and define diversity for students so that when we consider which groups of people are affected, there is a way to connect race to power relationships that may place marginalized people in a harmful setting. With standard Justice 12 and Justice 13, the verbs, describe and explain, within the standard provide a directive that I could incorporate into my assessments or activities. These verbs would guide students to specifically address the justice issues from a common perspective of unfairness and rights and freedoms.

Moreover, Sadler (2004) recognized that teaching through SSI requires a component of morality that cannot be left to chance. The teacher needs to create an environment that encourages sharing of ideas where all views are respected. The values of the individual students can result in them seeing the same evidence and arguing different viewpoints (Rundgren et al., 2016). The more a teacher scaffolds the classroom to include discussions of morality within the context of the social justice issue, the more likely students will become justice-oriented citizens (Chowdhury et al., 2020b).

**Student Shifts in their Perceptions of Equality and in Focus on Needs of Citizens in our Communities**

Doğanay and Öztürk (2017) found that students had shifts in views of human rights after eighth grade students in Turkey participated in long term lessons focusing on socioscientific issues with a human rights focus. In particular, students developed positive attitudes toward developing a standard of living that ensured access to adequate...
food, clean water, and food security. These findings are similar to those that I found with my students as they experienced shifts in perceptions of equality and needs of people.

Within the Basic Social Justice Orientation Scale developed by Hülle et al. (2018), questions targeted one of four social justice perspectives: equity, needs, equality, and entitlement. My students showed a shift toward more equality and needs of people; through class discussions my students and I defined equality to mean not literal equality in terms of material items but rather in terms of equal access to healthy air, food, and water. The lesson on food deserts was designed for students to become aware of the challenges to health and wellbeing that can arise when people do not have access to healthy food options. The unit that focused on Cancer Alley was designed to elucidate the risks that can arise when citizens are exposed to unhealthy air quality, which is often associated with poverty and poor living conditions. Both of these units were geared toward the needs and equality aspects of social justice. Students’ responses to Likert-scale questions in a survey administered before and after social justice instruction provided evidence of their shift in perceptions of equality and on needs of citizens. Survey prompts that addressed topics of equality included:

- It is just if all people have the same living conditions

- A society is just if there are only minor income disparities between people

- It is just if income and wealth are equally distributed among the members of our society
The mean of student responses in the survey administered before the lessons fell between disagree and neutral, but after the lessons, the mean of responses was at neutral. The Wilcoxon signed rank test demonstrated a significant difference in the responses.

There were three survey prompts that addressed student views on Needs of the Community:

Item A: A society is just if all people have sufficient nutrition, shelter, clothing as well as access to education and medical care

Item E: A society is just if it takes care of those who are poor and needy.

Item J: It is just if people taking care of their children, or their dependent relatives receive special support and benefits.

The mean responses of students on the Likert scale shifted from neutral before lessons to agree after lessons. Students began to identify needs as not just giving people handouts, but ensuring that their access to clean water, air, and healthy food are essential. My findings are similar to the findings of Herman et al. (2020) who found that postsecondary students who participated in a place-based environmental education course experienced a shift in their views of whose perspectives (park rangers, ecologists, Native Americans, government) were relevant to the reintroduction of wolves to Yellowstone National Park; students were more likely to put themselves in the perspective of others. The impact of the students participating in this place-based unit encourages me to incorporate a more localized place-based setting to my lessons.
The final unit, wrongful incarceration, was most closely related to the social justice issue classified as entitlement in the survey: the distribution of privileges based on ascriptive qualities. My students had a mean response score of 2.79 in the pre survey, indicating that their feelings fell between disagree and neutral. After participating in the lessons, their mean response was 2.67, still within the disagree and neutral range. However, students reflected an emotional response toward those wrongfully incarcerated: “I felt for some of the people” and “it helped put things in perspective and helped me see what other people are going through”. I am not surprised to find my students maintaining a score within the neutral range for entitlement, they seemed to wrestle with the statements:

Item D: It is just if members of respectable families have certain advantages in their lives.

Item F: It is just if people who have achieved good reputation and wealth profit from this later in life.

Item L: It is fair if people on a higher level of society have better living conditions than those on the lower level.

The students in this study attended a private Catholic school and many of them may have felt that some of the identifiers resonated more with their family station. In addition, I would not want to see the students to shift toward agree more, as that would indicate they were adjusting to a more entitled perspective.
While I found a shift in student views of needs and equity, entitlement did not show a shift. Johnson et al. (2019) found that in a study of university students who participated in experiential learning opportunities of inequities, shifts in ideology that were founded on areas of privilege were harder to attain than shifts in equality that were unrelated to identity. The authors found that when issues were more related to identity, such as income level and privilege, the issue or identity was more ingrained and harder to shift because of the social reinforcement that occurred by being surrounded or associating with people of similar economic level or privilege. This may shed some light on why I was able to see shifts in needs of the community but not as much in shifts of entitlement. The entitlement statements may have been too personal; several of my students live in affluent neighborhoods and are much more removed from living conditions that lack privilege and means. Sainz and Jacott (2020) also found that issues related to economic level were more complicated for adolescents to consider, because it was often a topic that was not a part of their individual daily lives. Sadler et al. (2004) found that among secondary students the arguments that were most convincing to the students were the ones that aligned with their already-held beliefs; students needed to be challenged to explore and investigate alternative viewpoints.

After completing the three units, students demonstrated through survey data, journal responses, and artifacts a shift in their views of what defined equality and needs within the community. Students did not demonstrate a shift in equity and in entitlement. The survey that was implemented within this study was the Basic Social Justice Orientation scale whose purpose was to order justice-related attitudes and to examine
these attitudes toward distribution on a societal level (Hülle et al., 2018). The social justice issues presented in this study did not necessarily tackle issues that addressed entitlement as presented in the survey. Additionally, the application of equity questions in the survey focused more on equitable distribution of resources as compared to effort imparted. For example, Item H: A society is just if differences in income and assets reflect performance differences between people.

Upon reflection, the analysis of the survey results did not provide the precise information I was anticipating obtaining from this survey. The question format and positionality did not lend itself to reflecting the perspectives of students as richly as the open-ended questions and the journal reflections did. Having recorded interactions of students during the lessons to capture their views in context would have provided an interesting layer of observations as well.

Ethics and morality have been a component of SSI and decision making. The inclusion of morality discussion in SSI is a natural fit that allows students to consider their views about the issue at hand and should be an essential component of the instruction. When students have the opportunity to consider moral implications they are able to consider multiple viewpoints (Sadler, 2004a; Zeidler et al., 2002). Sadler and Zeidler (2004) found that among 20 college students investigating issues such as gene therapy and cloning, all students relied on morality at some point in the decision-making process. Students referenced religion, personal experiences, and popular culture as some of the aspects that influenced their moral views of the situation. These findings were similar to those of Bell and Lederman (2003) in a study of 21 university students on the
role of NOS in decision making; rather than relying on NOS, they relied more on personal and ethical perspectives. Guiding students to support their decisions with their scientific knowledge would increase the reliance on the tenet of NOS of empirical evidence.

**Students Were Engaged and Enjoyed Studying Biology from a Perspective of Social Justice.**

Use of socioscientific issues in instruction has been established to improve engagement of students in decision making of controversial issues (Friedrichsen et al., 2016; Hancock et al., 2019; Herman, 2018; Herman et al., 2020; Sadler et al., 2016b; Sadler & Zeidler, 2005b). Students in this study self-reported that they enjoyed studying science using topics of social justice as a theme to organize and understand content. Of the 78 students who provided journal entries assessing their perspective of learning with social justice issues, 63 of them responded with favorable views. Within this group, 20 students enjoyed the topics, 14 appreciated the relevance to real life, and 23 mentioned how it helped them understand the material better.

Garii and Rule (2009) found that often when mathematics or science teachers attempted to incorporate social justice issues within the content, only one of the two is effectively taught. Some of my students felt this way as well; they enjoyed learning about the social justice issue and understood the content but did not see the connection between the two. Similarly, Dimick (2012) conducted a study focused on social justice issues within an environmental science class and found that while students were engaged and interested in the content and unit's focus, they did not view their efforts of river clean
up as a scientific endeavor because they did not follow the traditionally taught scientific method of experimentation. Cian (2020) found that socioscientific reasoning is not transferable to all socioscientific issues; students may more readily have connections to issues such as cancer or vaccination rather than others such as food insecurity or nuclear power. Similarly, my students may have lacked experiences related to food insecurity and thus issues of food deserts. Wrongful conviction was another area with which they did not have a personal connection. Basu and Calabrese Barton (2007) interviewed students about their perceptions of science and students revealed that if the topic was relevant to them and solved a problem, they were more likely to be invested in studying the topic. A review of literature also found that emotionally charged topics (i.e. human cloning, or wrongful incarceration) had a greater impact on students’ ethical sensitivity than topics that needed explanation (i.e. GMOs or food deserts) in order for students to recognize the issue involved (Van Der Leij et al., 2022).

Students self-reported that they enjoyed the experiences of studying biology from a perspective of real-world issues. However, as some of my students indicated that they did not necessarily see the connections, the scaffolded practices discussed previously could help them see the connections between the social justice issues and the role of scientific understanding to help understand the underlying causes or consequences.

**Unexpected Findings:**

Several factors emerged that were unexpected during the course of this study. The first emergence was the misinterpretation of the meanings of the words just and equity. I had not considered that the use of the word just would confuse students even
when read within the context of a situation. Students were familiar with the definition of justice but did not connect the adjective form of just to its noun counterpart. This confusion was addressed by adding a parenthetical explainer of (morally right and fair) after each use of the word just in the post-survey that was administered to students.

The second term that was a challenge in defining for several students was equity. Many students interpreted equitable to be synonymous with equal. A few interpreted the use in terms of financial equity; this was surprising given that students ages ranged from 14-16 and they have not yet taken an economics course or personal finance. I did not expect the confusion with word equity as described, but I should have been prepared for the assumption that it had the same meaning as equality, as this is an occurrence among people of all ages (Dome, 2022; Paul, 2019). As I teach units of social justice in the future, I will be sure to address the difference in definitions early.

I was not expecting to find that students did not shift in their perceptions of inequities but did so in terms of inequalities. After participating in the units of instruction, student perspectives tended more toward agreeing with equality among citizens. As a class we discussed the concept of all people having the same living conditions to not mean all people would have the same type of home and transportation, but rather they would have the same access to clean air, water, and healthy food options. However, we did not spend time delving into the underlying causes of inequities and disparities of living conditions. Had we done so, I might have seen different outcomes.
Reflection on Framework

This study was centered on the framework of critical theory, culturally relevant pedagogy, and constructivist learning, and based on Gorski’s (2008) definition of a decolonized classroom. While Gorski’s framework provides for a focus for creating a classroom that takes a critical perspective, honors contributions, and tackles difficult topics, it does not provide for reflective praxis. A more comprehensive and evolving version of a decolonized classroom would incorporate regular reflections on instructional goals and a commitment to underlying issues of systemic racism. The use of reflective praxis to ensure that the teacher is including issues of systemic racism can provide a counternarrative to the mainstream instructional practices in science classrooms (Gist, 2014; King & Pringle, 2019).

Implications for Teachers

SSI has become an established model for instruction that provides real-world concepts for students to apply scientific core ideas and practice reasoning skills (Birmingham & Calabrese Barton, 2014; Patterson & Gray, 2019; Pelch & McConnell, 2017; Zeidler et al., 2019). This study has shown that the engagement of students with science content is increased when they are given the opportunity to explore SSI from a basis of social justice issues; students also show a greater ability to identify issues of social justice through SJSSI. The SSI framework consists of three components: (1) introduce students to a focal issue, (2) provide them with scientific content through experiments and exploration, and (3) synthesize the material with a response or product (Sadler et al., 2016b). Teachers can modify this framework by selecting a focal issue that
centers on a social justice issue. In doing so, considerations can be made at each stage of the SSI process (Table 5.1).

**Table 5.1**  
*Adjustments to SSI sequencing to include additions for social justice considerations*

<table>
<thead>
<tr>
<th>Focal Issue</th>
<th>Scientific Content</th>
<th>Synthesis of Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Selection of issue with a social justice focus</td>
<td>Intertwine instruction of science with social justice</td>
<td>Guide students in considering counterviews</td>
</tr>
<tr>
<td>Selection of an issue with emotional relevance</td>
<td>Select social justice standards (Chiariello et al., 2018)</td>
<td>Guide students to justify their response through scientific evidence and reasoning</td>
</tr>
<tr>
<td>Selection of an issue with place-based connection</td>
<td>Foster an atmosphere where openness of ideas are valued</td>
<td>Explore and investigate underlying causes for injustice</td>
</tr>
<tr>
<td>Define relative terms: just, equity, needs</td>
<td>Practice explicit instruction of social justice issue</td>
<td></td>
</tr>
</tbody>
</table>

**Selection of Issue**

This modification of the SSI model begins with an issue of social justice, one that influences social, political, and economic structures that prevent some people from participating as full partners in social interaction (Fraser, 2007; Westheimer & Kahne, 2004). Selection of the issue is the first step for the teacher, and sets the stage for success with the students. The recommendation is also that the issue be relatable and have an emotional connection (Magee et al., 2020; Mensah, 2011). When social justice issues are relevant to the lives of the students, either through experiences (Basu & Calabrese Barton, 2007; Cian, 2020; Herman et al., 2020) or emotional connection (Bush et al., 2020; Mezirow, 2009; Van Der Leij et al., 2022), students are more apt to be engaged and motivated to participate in the learning process (Buxton, 2010; Herman et
al., 2020; W. Powell, 2021). The topic for my final two lessons proved to be engaging for students. Many students have had an emotional connection to a diagnosis of cancer within their family, and if not, a case study application could provide the emotional connection. While students likely did not have a personal connection to wrongful incarceration, the use of specific cases of individuals who were wrongfully incarcerated gave them a concrete example that motivated them to understand the topic of DNA and DNA testing. Just as Lotter et al. (2019) used a fictional case as part of a project-based learning unit, an actual case of a person who may still be living is an engaging and intriguing opportunity.

**Explicit Instruction**

Gandolfi (2017) found in a study of secondary science instruction of Nature of Science (NOS) that explicit instruction allowed for rich dialogue, student interest, and engagement with content. An explicit discussion of the social justice connection may provide the same student outcomes in an SJSSI unit. My students struggled with terminology related to social justice issues: defining equity was not intuitive to them. Students either used the terms equity and equality interchangeably (Dome, 2022; Paul, 2019) or they interpreted the word equity in terms of financial applications. To effectively address issues of social justice, direct instruction should begin with relevant terminology to establish a consistent basis of knowledge along with scaffolded support of connecting science to social justice issues. Instruction should continue with an investigation into the different groups of people affected; these conversations will include issues of systemic racism which teachers should be prepared to tackle (Gorski, 2008).
**Scaffolded Support**

Swedish students studying issues surrounding sustainability development were influenced by contextual presentation. If students were presented with environmental and social factors to consider together, they were more influenced to consider both than if they were introduced to these concepts separately. Meaning, that students need the context of society and health/environment to fully connect the science to the social issues (Berglund & Gericke, 2016). Teachers need to provide scaffolding for students by interweaving the science instruction with the social justice issue. Finkel (Finkel, 2018) described preparing teacher candidates to teach social justice issues within science by having the candidates focus on three guiding questions with their students: “[1] Who benefits from this knowledge and/or its application in society? Who does not? [2] Who participated in the development of these ideas? Who got credit? [3] Who has access to this knowledge? Who does not?” (p. 53). These scaffolding questions would encourage students to dig deeper into the science content and to the underlying issues.

My students understood that healthy food was important, but they often neglected to connect that to the function of the various biological macromolecules in a person’s diet during our first social justice lesson. When middle school students were provided with scaffolded support in crafting arguments that incorporated scientific reasoning into the social justice issue, there was greater success (Belland et al., 2015), and even when students had the opportunity to develop argumentations in collaboration with classmates, they produced more effective argumentations of SSI (Evagorou & Osborne, 2013). In fact, the instructional strategy of argument-driven inquiry prescribes an opportunity for
students to gather feedback from their classmates on their arguments and to make any needed adjustments (Sampson et al., 2011; Walker & Sampson, 2013). My students likely would have benefited from this scaffolded support or collaboration as well. This key component of social constructivism fosters students’ abilities to participate in sense-making rather than just being passive learners that receive content (Hodson, 1998; Vygotsky, 1978).

I also had a missed opportunity during the wrongful incarceration unit, where I introduced the concept of implicit bias at the beginning, but I did not have them reflect back on the topic of implicit bias as they investigated their cases of wrongful incarceration. In having students review an individual case they would have benefitted from a conversation tying back to implicit bias “how could implicit bias have played a role in the conviction of the accused?”. Drawing their attention to the underlying causes that resulted in the wrongful conviction and sharing those observations would have provided an opportunity to, again, address systemic racism and underlying societal instances of injustice.

**Limitations.**

This study has a few limitations. First, the study was conducted in a private school that is not bound by the regulations of educational oversight and debates surrounding Critical Race Theory that may make some educators hesitant in pursuing social justice issues. Second, this study was conducted within one single classroom where teacher served also as researcher; implementing this practice in a classroom that can be observed by someone outside of the teacher may provide different perspective.
This would be the next step as described by Mills (2018), in which the teacher-researcher shares what was learned with colleagues to explore. Souto-Manning (2012) argues that teachers should consistently position themselves as researchers to reflect on their practice and seek to improve their pedagogy, but this can result in teachers shifting between an insider/outsider position (Bukamal, 2022). Bukamal (2022) describes this insider/outsider transitioning as one in which a researcher finds themself as part of the group being studied and occasionally as outside of that group. It is a careful transition for an individual researcher, such as a classroom teacher, to make as s/he moves back and forth between roles.

Finally, one of the limitations was not fully engaging the students with conscientização, or critical consciousness. In this study the students were exposed to issues of social justice and asked to connect the science and to describe the injustice; however, they were not required to examine the underlying societal causes that contributed to the social injustice. Exploring the critical consciousness related to the issues would have more effectively represented the goals set by both Paolo Freire (2018) and Gloria Ladson-Billings (1995).

Future Research

Future research could center on some of the additions or recommendations made to the SSI model as presented in Table 5.1. For example:

1. How do students respond to instruction that is centered on a topic that is either emotionally relevant or place-based relevant to them?
2. Do students become more able to identify issues of social justice if the instruction is centered around the instructional standards of social justice as provided by Learning for Justice (Chiariello et al., 2018)

3. How does student argumentation shift when required to consider counterviews in their investigations?

Additionally, the school where this study was conducted requires of all graduating students to conduct a social justice research project in their Senior year. I would like to follow these students to their senior year social justice issues project and see how many of them incorporate issues that have a connection to science-based topics, whether it be biology or otherwise. It would also be interesting to see how many of these students then go on to study science in post-secondary education. Finkel (2018) posits that social justice implementation is necessary to bolster diversity in future STEM professions and engaging students in solving issues relevant to their communities, perhaps their exposure may encourage some pursuits of STEM careers.
References


Cancer risk in Louisiana town nearly 50 times higher[video]. (2019). https://www.youtube.com/watch?v=MGNtMkFJkJg


Appendix A: Parental Consent

Dear Parents, Guardians, and Students,

My name is Stephanie Bailey, and I am a doctoral candidate in the Department of Instruction & Teacher Education in the College of Education at the University of South Carolina. I am conducting a research study as part of the requirements of my degree in Teaching and Learning, and I would like to invite your child to participate.

I am studying the role of using relevant issues of social interest in science teaching. If you decide to participate, you will be asked to complete some surveys about social justice issues and science learning as well as participate in a group discussion about social justice in science class.

In particular, we will discuss topics such as locations of healthy food options, using DNA in exoneration of innocent people, as well as DNA testing and its ability to identify racial background. You may feel uncomfortable answering some of the questions. You do not have to answer any questions that you do not wish to answer. The group discussions will take place at Cardinal Newman during the school day and should only last about 20 minutes. The session will be videotaped so that I can accurately transcribe what is discussed. The tapes will only be reviewed by members of the research team and destroyed upon completion of the study.

Participation is confidential. Study information will be kept in a secure location. The results of the study may be published or presented at professional meetings, but your identity will not be revealed. Surveys will be conducted using a confidential identifier that will not be traceable back to student identity.

Others in the group will hear what you say, and it is possible that they could tell someone else. Because we will be talking in a group, we cannot promise that what you say will remain completely private, but we will ask that you and all other group members respect the privacy of everyone in the group.

Participation, non-participation, or withdrawal will not affect your grades in any way. If you begin the study and later decide to withdraw, you will not be penalized in any way. Nor will anyone who participates receive an advantage.

I will be happy to answer any questions you have about the study. You may contact me at sbailey@cnhs.org or my faculty advisor, Christine Lotter at lotter@mailbox.sc.edu.

Thank you for your consideration. If you would like to participate, please complete the attached information and return to me by August 25, 2021.
Participation in Social Justice Action Research in Science

Please check the appropriate space, sign your name, and enter the date. Please have your child return this portion of the letter to his/her teacher by the following Due date: **8/25/2021**

<table>
<thead>
<tr>
<th>Please check one of the options:</th>
<th>Use of classroom documents for action research (no one but project staff will view student work or videotapes)</th>
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</thead>
<tbody>
<tr>
<td>_________ Check here OR</td>
<td>I give my permission for my child to take part in the documentation efforts, which may include videotaping, surveys, classroom testing and observations.</td>
</tr>
<tr>
<td>_________ Check here</td>
<td>I <strong>DO NOT</strong> give my permission for my child to take part in the documentation efforts.</td>
</tr>
</tbody>
</table>

________________________________________  __________________________
Signature, Parent/Guardian                     Date

________________________________________
Signature, Student
Student’s Name (Printed)
Appendix B: Food Desert Lesson

Food Deserts

Discuss

Studies show that certain racial groups are disproportionately affected by obesity. These problems may be worse in some U.S. communities because access to affordable and nutritious food is difficult. This is especially true for those living in low-income communities of color and rural areas with limited access to supermarkets, grocery stores or other food retailers that offer the large variety of foods needed for a healthy diet such as fresh fruits and vegetables, whole grains, fresh dairy and lean meat products. Instead, individuals in these areas may be more reliant on convenience stores, fast food or similar retailers, or they may not have enough money to afford the higher prices. These areas of limited access are called “food deserts.”

Let's look at this from a biological perspective. Why would food deserts lead to greater incidences of obesity? Make a claim, support with evidence, and provide reasoning.

Respond Here →

Now, let's connect this to inequities among communities. Knowing this information, and what you read/watched, consider the occurrences of pre-existing conditions that may make some communities at a greater risk of complications due to COVID-19. Make a claim, support with evidence, and provide reasoning.
Appendix C: Cancer Alley

You are advocating on behalf of the citizens of Gordon Plaza of Louisiana who live in the region that has become known as Cancer Alley.

You will write a letter to the state representatives of Louisiana. Your job is to explain to the representatives what the concern is and why it is a problem for the residents. Be sure to explain how this affects the cells in the body. Come up with a reasonable, practical proposal that could alleviate some of the stress.

Each topic above should be a mini paragraph.

Refer to the rubric included for guidance on grading.
Appendix D: DNA Exoneration Lesson

Create a poster:
How can science be used to address inequities, such as wrongful convictions, in society?

Include:
- A brief description of your case
- An explanation of how exoneration was achieved
- A connection between the science we have learned and this exoneration
- Use images/diagrams/symbols to explain the information you are trying to convey